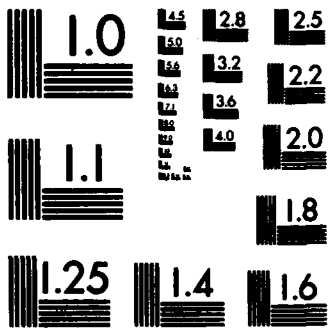
AD-A133 946 INVESTIGATION OF AN ERROR THEORY FOR CONJOINT MEASUREMENT METHODOLOGY(U) OHIO STATE UNIV RESEARCH FOUNDATION COLUMBUS T E NYGREN MAY 83 AFOSR-TR-83-0860 1/2

UNCLASSIFIED AFORR-82-0175 F/G 12/1 NL


1.0
4.5
5.0
5.6
6.3
7.1
8.0
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

AFOSR-TR- 83-0860

13

RF Project 763025/714404
Final Report

the
ohio
state
university
research foundation
1314 kinnear road
columbus, ohio
43212

AD-A133946

INVESTIGATION OF AN ERROR THEORY FOR CONJOINT MEASUREMENT METHODOLOGY

Thomas E. Nygren
Department of Psychology

For the Period
April 1, 1982 - March 31, 1983

UNITED STATES AIR FORCE
Air Force Office of Scientific Research
Bolling Air Force Base, D.C. 20332

Grant No. AFOSR-82-0175

May, 1983

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AFOSR-TR- 83-0860	2. GOVT ACCESSION NO.: AD-A133946
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Investigation of an error theory for conjoint measurement methodology.	5. TYPE OF REPORT & PERIOD COVERED: Final, 3/1/82-3/31/83
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Thomas E. Nygren	8. CONTRACT OR GRANT NUMBER(s): Grant No. AFOSR-82-0175
9. PERFORMING ORGANIZATION NAME AND ADDRESS: The Ohio State University Research Foundation, 1314 Kinnear Road, Columbus, Ohio 43212	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 2313/D9 61102F
11. CONTROLLING OFFICE NAME AND ADDRESS: Air Force Office of Scientific Research/NL, Bolling AFB, DC 20332	12. REPORT DATE: May 1983
	13. NUMBER OF PAGES: 168
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

conjoint measurement
error theory
SWAT
axiom system

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of an attempt to propose a basis for an error theory of conjoint measurement methodology. Conjoint measurement methodology offers a new and potentially useful approach for obtaining psychological scale values for components of multidimensional attributes. This report describes the mathematical foundations of this methodology as well as a means of evaluating the fit of an additive conjoint measurement model to a three factor design. For each of the critical axioms of conjoint measurement, proportions

(continued on back)

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Abstract, continued

of errors that would be expected by chance for different conditions of simple independence are examined. In addition, a computer-based algorithm that can be used to perform specific kinds of conjoint analysis has been generalized and documented as a technique for assessing the fit of an additive model to a set of data. The program is called SWAT and its current state of development is described in this report. Finally, the appendices provide a step-by-step explanation of data deck arrangements for SWAT as well as some actual printouts from the program.

AFOSR Grant Number 82-0175

Final Technical Report

May, 1983

INVESTIGATION OF AN ERROR THEORY FOR CONJOINT MEASUREMENT METHODOLOGY

THE OHIO STATE UNIVERSITY

404C W. 17TH AVENUE

COLUMBUS, OHIO 43210

DR. THOMAS E. NYGREN

Controlling Office: USAF Office of Scientific Research/NL

Bolling Air Force Base, DC 20332

The views and conclusions in this document are those of the author and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of the Air Force Office of Scientific Research of the U. S. Government.

ACKNOWLEDGEMENTS

The idea for this project was generated while the author was participating in the 1981 USAF-SCEEE Summer Faculty Research Program. Pilot work was supported by the Air Force Aerospace Medical Research Laboratory (AFAMRL), Human Engineering Division (HE), Wright-Patterson AFB, Ohio 45433. In particular, collaboration with Mr. Gary Reid at WPAFB was an essential ingredient to the initiation of this project.

The author gratefully acknowledges the support of the Air Force Office of Scientific Research for funding this project under Grant AFOSR-82-0175.

ABSTRACT

This report presents the results of an attempt to propose a basis for an error theory of conjoint measurement methodology. Conjoint measurement methodology offers a new and potentially useful approach for obtaining psychological scale values for components of multidimensional attributes. This report describes the mathematical foundations of this methodology as well as a means of evaluating the fit of an additive conjoint measurement model to a three factor design. For each of the critical axioms of conjoint measurement, proportions of errors that would be expected by chance for different conditions of simple independence are examined. In addition, a computer-based algorithm that can be used to perform specific kinds of conjoint analysis has been generalized and documented as a technique for assessing the fit of an additive model to a set of data. The program is called SWAT and its current state of development is described in this report. Finally, the appendices provide a step-by-step explanation of data deck arrangements for SWAT as well as some actual printouts from the program.

TABLE OF CONTENTS

Page

I. INTRODUCTION

Subjective scaling techniques are an integral part of much of social science research. In many situations it is assumed that the variable of interest is a complex phenomenon that is multideminsional in nature. That is, it is recognized that the ordering of scores produced by an individual on this variable may be based on the joint effects of two or more independent variables.

Often the researcher may be interested in one or both of the following basic questions. First, can the composition rule by which the independent variables combine to produce the joint effect on the dependent variable be established empirically? Second, is it possible to obtain initial measurements for the independent variables themselves, or only for their resultant joint effects? That is, can the independent and dependent variables be scaled simultaneously according to some specified composition rule in a way that preserves the order of the joint effects in the data? This question, as Tversky (1967) points out, is the *conjoint measurement problem*, and the composition rule is the *conjoint measurement model*.

There are, of course, many composition rules that might be hypothesized in psychological theories. The simplest such rule is an additive one which suggests that the independent variables combine in an independent additive fashion to produce the joint effect. For example, let a_1 be a level of Factor A_1, a_2 be a level of Factor A_2, and a_3 be a level of Factor A_3. We might hypothesize that the joint effects of these three factors could be described as

$$f(a_1,a_2,a_3) = f_1(a_1) + f_2(a_2) + f_3(a_3) \qquad (1)$$

where f, f_1, f_2, and f_3 are separate and identifiable numerical functions. Additive models like the three-factor model illustrated in Equation 1 have been and continue to be an important part of many psychological theories. Until recently, however, even for this simple model, there has not been a satisfactory means by which one could simultaneously estimate all four of the "f" functions above. Conjoint measurement theory provides a means to do this and herein lies its power. Just as important, however, is the result of the theory which indicates that only ordinal relations are required among the data points in order to produce resultant scales unique up to an affine transformation. The implications of this result will become more apparent following the presentation of the basic theory of conjoint measurement in Section II. Section III then reviews some of the literature examining the conjoint measurement axioms. Then in Section IV, the findings from the present research are reported. Finally, Section V discusses some of the implications of this research and suggestions for further study.

II. FOUNDATIONS OF CONJOINT MEASUREMENT

Prior to an introduction to the mathematical foundations of conjoint measurement it might be useful to review two terms that are generally distinguised in the literature (Emery and Barron, 1979; Green and Rao, 1971; Green and Srinivasan, 1978). First, we define conjoint measurement as the procedure whereby we specify for a given combination rule, the conditions under which there exist measurement scales for the dependent and independent variables, such that the order of the joint effects of the independent variables in the data are preserved by the numerical composition rule. We then define conjoint analysis (sometimes referred to as numerical conjoint measurement) as the procedure whereby the actual numerical scale values for the joint effects and the levels of the independent variables are obtained. Thus, there are effectively two separate and independent processes in the conjoint measurement methodology. First, one attemps to find the appropriate combination rule and then, assuming the rule is valid, finds numerical functions that "best" fit the observed order of the joint effects in the data according to the specified rule.

Given the above presentation of the basic definitions of conjoint measurement, we can now proceed with a detailed discussion of the more interesting three factor simple polynomial models as discussed by Krantz and Tversky (1971) and by Krantz, Luce, Suppes, and Tversky (1971). There are four simple models that will be discussed. They are the familiar additive model (A + B + C), the multiplicative model (A * B * C), the distributive model (A * [B + C]), and the dual-distributive model (A + [B * C]).

Krantz and Tversky (1971) have previously discussed a number of ordinal properties that are necessary though not sufficient for these four models to hold. Since these properties form the basis of the research described below and are examined in the computer program that is used as a diagnostic method, they will be briefly summarized here. The intent here, as in the Krantz and Tversky (1971) paper, was not to present an axiomatization for each of the four models mentioned above, but rather to describe a set of ordinal properties that may be used as diagnostic tools in differentiating among these four models as viable composition rules.

Simple Independence

We begin with the fundamental property of *independence* which can be checked separately for each of the three factors. We say that

A_1 is <u>independent</u> of A_2 and A_3 whenever

$$(a_1,a_2,a_3) \succsim (b_1,a_2,a_3) \text{ if and only if}$$
$$(a_1,b_2,b_3) \succsim (b_1,b_2,b_3) \ . \tag{2}$$

Thus independence of A_1 asserts that if $a_1 > b_1$ for some combination of levels of Factors A_2 and A_3, then this relation will hold for any other combination of levels of A_2 and A_3. Every test of independence of A_1 with A_2 and A_3 requires a 2x2x2 matrix with two levels of Factor A_1 and two combinations of $A_2 \times A_3$. Thus the total number of possible tests of the property in this case would then be

$$T = \binom{n_1}{2} \binom{n_2 * n_3}{2} \tag{3}$$

where n_i is the number of levels of Factor i.

Although this property is clearly necessary for an additive model, it need not hold for any of the other three simple models. This is because these latter models have multiplicative factors which might not preserve the order if negative or zero scale values are allowed. If all scale values for multiplicative factors are positive, however, the ordering of the stimuli cannot be reversed without violating the property. If a zero value is permitted for a multiplicative factor, then a degenerate case is produced regardless of the levels of the other factor(s). If negative values are permitted then a legitimate order reversal may occur. Hence, if only positive values are permitted, the independence property is necessary for all four models. If zero or negative values are permitted then we must define a more general property labelled <u>sign dependence</u>. This property has been examined in detail by Krantz and Tversky (1971) and will not be discussed here.

Joint Independence

A second form of independence can also be examined in our three factor models. The property, known as <u>joint independence</u>, states that

A_1 and A_2 are <u>jointly independent</u> of A_3 whenever

$$(a_1,a_2,a_3) \succsim (b_1,b_2,a_3) \text{ if and only if } \quad (4)$$

$$(a_1,a_2,b_3) \succsim (b_1,b_2,b_3) .$$

Joint independence of A_1 and A_2 with respect to A_3 indicates that if one combination of A_1 and A_2 is greater than another at a fixed level of A_3, (i.e., $[a_1,a_2] > [b_1,b_2]$ at a_3), then the ordering should be preserved for any other level of the third factor (b_3). If joint independence holds for all pairs of factors, then this implies that independence holds for a simple factor. However, the converse is not necessarily true. If simple independence holds for all factors, this does not imply that joint independence will be satisfied for all pairs of factors.

We can, of course, state two other forms to the joint independence property for A_1 and A_3 of A_2, and A_2 and A_3 of A_1. If we again restrict our scale values for all factors to be positive, then it is clear that joint independence must hold in all three forms for the additive and multiplicative models. However, for the distributive model of the form $A_1*[A_2 + A_3]$, only A_2 and A_3 must be jointly independent of A_1. For any given set of finite observations, it is important to note that all three forms of joint independence may hold even if the model is, in fact, distributive. However, it appears that as the size of the design increases, the more likely it is that only the one appropriate form will hold if the model is truely distributive.

Double Cancellation

The third property examined by Krantz and Tversky (1971) is one that has already been discussed with respect to the Luce-Tukey (1964) axiomatization for the two-factor additive model. This is the property usually referred to as double cancellation or Luce-Tukey cancellation and is stated for Factors A_1 and A_2 as

$$\begin{aligned}&\text{If } (a_1,b_2,a_3) \gtrsim (b_1,c_2,a_3) \text{ and}\\ &(b_1,a_2,a_3) \gtrsim (c_1,b_2,a_3) \text{ then,}\\ &(a_1,a_2,a_3) \gtrsim (c_1,c_2,a_3).\end{aligned} \tag{5}$$

Note that double cancellation requires at least three levels of each of Factors A_1 and A_2, and deals with only two such factors at a time. Hence, it must be satisfied for all pairs of factors for any of the four models described above when the scale values are all positive. If Factors A_1 and A_2 have n_1 and n_2 levels respectively, then there will be

$$T = \binom{n_1}{3} * \binom{n_2}{3} \tag{6}$$

possible tests of double cancellation for these two factors.

Distributive Cancellation

Up to this point we have not presented a means of distinguishing between the distributive and dual-distributive models. The final two properties attempt to do this. We first describe a property known as distributive cancellation.

Distributive cancellation is satisfied if and only if

$$\begin{aligned}&(a_1,b_2,a_3) \gtrsim (d_1,c_2,c_3)\\ &(b_1,a_2,a_3) \gtrsim (c_1,d_2,c_3) \text{ and,}\\ &(d_1,d_2,c_3) \gtrsim (b_1,b_2,a_3)\text{, then}\\ &(a_1,a_2,a_3) \gtrsim (c_1,c_2,c_3).\end{aligned} \tag{7}$$

It can be shown that this property is a necessary condition for the distributive model to hold. However, distributive cancellation also holds in an additive representation. Hence, although this property can be used to support a distributive representation, it cannot be used to reject additivity. It is not necessary for a dual-distributive representation, however, and can be used as a means to differentiate between these two models.

Dual-Distributive Cancellation

The final property to be discussed for our three-factor models is dual-distributive cancellation. Formally, we say that

Dual-distributive cancellation is satisfied if

$$
\begin{aligned}
&(c_1,d_2,b_3) \succsim (a_1,c_2,c_3),\\
&(a_1,e_2,e_3) \succsim (d_1,b_2,e_3),\\
&(d_1,c_2,d_3) \succsim (e_1,d_2,a_3),\\
&(d_1,a_2,a_3) \succsim (b_1,e_2,d_3), \text{ and}\\
&(e_1,b_2,e_3) \succsim (c_1,e_2,e_3), \text{ then}\\
&(a_1,a_2,b_3) \succsim (b_1,b_2,c_3).
\end{aligned}
\tag{8}
$$

Dual-distributive cancellation is comparable to distributive cancellation in that is is necessary for both dual-distributive and additive representations. Hence, again it cannot be used to reject additivity. Since it is not necessary for a distributive representation, however, it can be used as a means of possibly distinguishing between a distributive and dual-distributive model. Note, however, that this property is extremely complex. It requires that five antecedent conditions from a 5x5x5 design be met in order for a test to even be possible. Hence, this property suffers from being empirically very difficult to evaluate.

Given this set of conditions, it should be possible to evaluate each of the four polynomial models mentioned above for a set of observations obtained from a factorial design. In each of the axiom conditions only ordinal information is required in order to adequately test these properties. Thus, it is sufficient to require each subject to merely present rank order judgments for each of the stimulus combinations generated by combining levels of the factors. As was discussed earlier, in most applications of conjoint measurement methodology it is the additive representation with restriction to the positive case that is of interest. Even for an additive model as small as 3x3x3, however, both the testing procedures for the properties mentioned above and the actual scaling procedure for obtaining the numerical scale values become extremely impractical without the aid of a computer based algorithm. Fortunately, several computer programs of both types have been developed during the past decade (Johnson, 1973; Kruskal, 1965; Nygren, 1982; Srinivasan and Shocker, 1973a, 1973b; Ullrich and Cummins, 1973; Takane, Young, and de Leeuw, 1980; Young, 1972).

Thus it is relatively easy to obtain for a given set of data (1) a list of violations of each of the axioms in Equations 2, 4, 5, 7, and 8 and (2) a best fitting additive scaling solution.

The real difficulty with conjoint measurement is that research efforts that have attempted to develop an error theory for this methodology have lagged far behind. Thus it is very difficult in practice to evaluate in a given situation how well the data is being fit by an additive model. The issue is, then, how do we decide how many violations of an axiom constitutes rejection of the axiom. In the next section we discuss recent research that has attempted to study this issue. In Section IV further research based on this project will be discussed.

III. DIAGNOSTIC EFFICACY OF AXIOMATIC CONJOINT MEASUREMENT

The title for this section comes from a very important paper published in 1979 by Emery and Barron. The study reported in that paper was one of a very few that have attempted to examine how well the axioms reported in Section II could in fact be used to differentiate among the simple additive, distributive and dual-distributive models. In particular, Emery and Barron were interested in the issue of misdiagnosis. That is, is it possible for a set of data to come from one simple polynomial model (e.g., distributive) but not be rejected as coming from a different model (e.g., additive)? This could occur if the rank order associated with one set of data does not violate any of the axioms associated with either its own generating model or some other model. In this case, the conjoint measurement axioms would be unable to reject the false model.

Emery and Barron (1979) generated 92 sets of data in three factors coming from either additive models (20 cases), distributive models (36 cases), or dual-distributive models (36 cases). Using the axiom testing procedure, PCJM, Emery and Barron found that all

20 of the additive data sets were diagnosed as coming from additive models. However, of the 36 sets from distributive models, only 23 were diagnosed as coming from a unique distributive model. Six of the remaining 13 sets were diagnosed as coming from an additive model and seven were diagnosed as coming from several possible distributive models. Of the 36 dual-distributive data sets, none were diagnosed correctly as coming from a dual-distributive model. Twenty-one of these sets were diagnosed as coming from an additive model, four and eleven were diagnosed as coming from either a unique distributive or multiple distributive model respectively.

The results just described are not very encouraging for those who would like to use the conjoint measurement axioms as diagnostic tools. Perhaps some other technique might be more useful. In an attempt to examine this possibility, Emery and Barron then looked as the usefulness of one of the numerical conjoint scaling procedures as a diagnostic tool. Specifically, they used the computed STRESS value and a measure of fit they called PRECAP that could be obtained from a scaling of the data based on the MONANOVA program (Kruskal, 1964, 1965). These scaling results were somewhat more encouraging than were those from the axiom tests, but misdiagnoses were still found.

These findings are very important to conjoint scaling methodology and point to the need for further research for increasing power in the diagnosis of the simple conjoint measurement models in real data. The research to be presented in Section IV attempts to meet this need by providing further insight into the properties inherent in these axioms. Our research project differs in several very important respects from the work of Emery and Barron. First, their data were error-free. That is, they generated their data in such a way as to fit one of the models perfectly. The approach taken in the research to be presented below is different in that we started in a sense in th opposite direction. We began with completely random data and added structure to it in several steps. Secondly, individual axioms were examined in detail in the present research. In particular, the conditional effects of satisfaction of one axiom, simple independence, on the occurrence of violations of the other axioms were examined.

This last difference is relevant for one other reason. It relates the current project to two other important studies on conjoint measurement methodology that investigated the axiom system. These papers are one by Arbuckle and Larimer (1976) and a follow-up note by McClelland (1977).

Arbuckle and Larimer (1976) used a Monte Carlo approach to invesitage the likelihoods associated with satisfying the conjoint measurement axioms in two-factor matrices of different sizes. In particular, they attempted to estimate the number of possible rankings in an rxc table that satisfy both independence and double cancellation, and that satisfy additivity. Although their study was extremely enlightening, it was faced with one rather difficult problem. The problem was simply that in many of their examples the samples were small, perhaps too small to give accurate estimates of the probabilities. Nevertheless, their results seemed to indicate that as r and c increased, the probability of satisfying double cancellation or additivity by chance becomes small. In addition, the proportion of rxc tables satisfying independence and double cancellation that are also additive decreases as r and c increase.

McClelland (1977) attempted to carry the work of Arbuckle and Larimer (1976) one step further in terms of accuracy by finding exact probabilities for those r x c tables small enough to allow for exact enumeration. In addition, McClelland's work is very interesting in that he attempted to find in greater detail some of the conditional probabilities for satisfying the additive conjoint measurement axioms. For example, the conditional probabilities of satisfying double cancellation given independence, and of satisfying additivity given independence or independence and double cancellation were obtained. As expected, results similar to those of Arbuckle and Larimer (1976) were obtained.

The Arbuckle and Larimer (1976) and McClelland (1977) papers suffer from several major limitations, however. First their examinations of the axioms were at a more global level than might be needed by the applied researcher. Second, and perhaps more important, the data sets were very small, coming from either a 3x3, 3x4, 3x5, or 4x4 design. Hence, interesting relations in three factors were not and have not been systematically investigated. The three papers cited above represent the only major contributions of this type that the author is aware of to the testing of the conjoint measurement axioms. Clearly, more detailed work is needed. In Section IV the results of one such additional study are presented. Concurrently, the author's computer-based algorithm for doing the axiom tests and the conjoint scaling will be discussed.

IV. SWAT ANALYSIS OF RANDOM DATA MATRICES

One attempt to develop a general diagnostic program for testing the conjoint measurement axioms was made by Holt and Wallsten (1974). Their program, CONJOINT, was designed to test each of the axioms mentioned above except for dual-distributive cancellation. CONJOINT was written in PL/1 and has been modified to run on an IBM 370 or Amdahl 470 operating system. Ullrich and Cummins (1973) developed two other programs, PCJM and PCJM2, written in FORTRAN to do essentially the same thing as CONJOINT. There are, however, several differences between the programs which make both very useful as diagnostic tools.

SWAT is a program developed by the author over the past two years that also provides tests of the axioms described by Krantz and Tversky (1971). SWAT is a combination of what the author believes to be the most useful parts of the CONJOINT and PCJM programs. First, it provides a more detailed analysis of violations of the axioms than does the CONJOINT program, especially for the critical axioms of simple independence and joint independence. Second, SWAT employs some of the same efficient algorithms used by Ullrich and

Cummins (1973) in their PCJM2 program for examining independence, joint independence, double cancellation, and distributive cancellation. SWAT, however, makes some very important corrections to logical and theoretical errors made by their PCJM2 analysis.

The major contribution of SWAT is that it allows the researcher to both test the axioms for additive conjoint measurement and obtain an additive scaling solution to the data all in one complete computer run. SWAT employs a modification of the algorithm for conjoint scaling first proposed by Johnson (1973). This simple, yet very useful, nonmetric regression procedure has been incorporated into SWAT and has been generalized to be more useful for applied research. The original version of the Johnson program, sometimes referred to as NMRG or NONMETRG, has been revised during this funding period to become an integral part of the SWAT procedure.

The combination of the axiom testing program with the scaling program provides much more flexibility to the applied researcher in analyzing a data set than was previously possible with separate programs. A number of options for the combined SWAT program have been introduced into the algorithm on the basis of the research conducted during this grant period. Given the previous theoretical discussion of the axioms and their interpretation in

Section II, it is now possible to discuss in this section how some of the findings from the present research have been and will be implemented into the SWAT program. It should be noted that the actual SWAT program is still being improved upon as more theoretical work is being done. The discussion below represents the current stage of SWAT development. In Section V a discussion of future needs and directions for continued research will be presented. Suggestions for revisions in SWAT will be included.

SWAT Methodology

The data shown in Tables 1 and 2 will be used to illustrate the research presented here in conjunction with application of the SWAT program. The values in the tables are rankings for each of four experimental conditions. These data were generated to first represent one subject's random rankings for each of the 27 stimulus combinations from a 3x3x3 design. This random or unconditional data matrix (Uncond) is shown in Table 1. One thousand such random data sets were generated. In addition, a second set of 1000 random data sets were generated for 64 stimulus combinations in a 4x4x4 design. For each of these 2000 data sets the rows and columns were next permuted so as to satisfy simple independence perfectly on the first of the three factors (Factor A). An example of one of these modified data sets in shown in the first nine rows of Table 2. This matrix will be described as coming from the Single condition. Next, each of the 2000 data sets were permuted so as to satisfy simple independence in two factors, Factors A and B. An example of a data set from this Double condition is presented in the middle of Table 2. Finally, each data set was permuted so as to satisfy simple independence in all three of the Factors A, B, and C. This is the Triple condition shown at the bottom of Table 2. The entire SWAT analysis for each of the four examples in Tables 1 and 2 is presented in Appendix 2.

Notation

Throughout the discussion of the foundations of conjoint measurement we have used the notation A_1, A_2, and A_3 to represent our factors. A different way to denote the factors will now be introduced. Although it may at first seem confusing to introduce this additional notation, it is necessary, since these notational changes are used rather extensively in the SWAT program. SWAT uses A, B, and C to represent the corresponding three factors. This will be illustrated in Tables 1-12.

Table 1

Example of a 3x3x3 Design for Ranked Observations:
Unconditional Data

Matrix	C	B	1	2	3 (A)
	1	1	21.0	13.0	24.0
	1	2	22.0	27.0	8.0
	1	3	14.0	2.0	9.0
	2	1	11.0	16.0	23.0
Uncond	2	2	3.0	7.0	4.0
	2	3	10.0	1.0	17.0
	3	1	15.0	5.0	26.0
	3	2	12.0	20.0	19.0
	3	3	25.0	6.0	18.0

Table 2

Example of a 3x3x3 Design for Ranked Observations: Data Martices Satisfy Simple Independence in One, Two or All Three Factors

Matrix	C	B	1	2	3 (A)
	1	1	13.0	21.0	24.0
	1	2	8.0	22.0	27.0
	1	3	2.0	9.0	14.0
	2	1	11.0	16.0	23.0
Single	2	2	3.0	4.0	7.0
	2	3	1.0	10.0	17.0
	3	1	5.0	15.0	26.0
	3	2	12.0	19.0	20.0
	3	3	6.0	18.0	25.0
	1	1	2.0	9.0	14.0
	1	2	8.0	21.0	24.0
	1	3	13.0	22.0	27.0
	2	1	1.0	4.0	7.0
Double	2	2	3.0	10.0	17.0
	2	3	11.0	16.0	23.0
	3	1	5.0	15.0	20.0
	3	2	6.0	18.0	25.0
	3	3	12.0	19.0	26.0
	1	1	1.0	4.0	7.0
	1	2	3.0	10.0	17.0
	1	3	11.0	16.0	23.0
	2	1	2.0	9.0	14.0
Triple	2	2	6.0	18.0	24.0
	2	3	12.0	19.0	26.0
	3	1	5.0	15.0	20.0
	3	2	8.0	21.0	25.0
	3	3	13.0	22.0	27.0

Simple Independence

SWAT allows one to test for simple independence among the factors, although the approach taken here is a combination of the approaches used in CONJOINT and PCJM2. The CONJOINT program tests for independence of factors by considering them two at a time. Independence for A of B would be checked by comparing the rank order of the cells for the levels of Factor A at each level of Factor B. Similarly, a check can be made for the independence of B at each level of A. SWAT actually uses the PCJM2 algorithm to test for independence as presented in the formula in Equation 2. That is, all possible tests of independence are checked. In the remainder of this section the SWAT analysis will be illustrated with the data in Tables 1 and 2 with the <u>Unconditional</u> and <u>Double</u> data matrices.

To illustrate the test of the property of independence in SWAT, let us look at the A x B matrix at fixed Level 1 of Factor C for the Double data matrix in Table 2. Note that in comparing the rank orders of the three <u>columns</u> of this matrix, there is perfect agreement. Hence, we say "B is independent of A" at Level 1 of Factor C. It is also the case, however, that "B is independent of A" at Levels 2 and 3 of C (the second and third matrices), and we can say simply that "B is independent of A." In a comparable manner we can look at the ranks of the rows for the A x B matrix at each level of C. Again, we find perfect rank order agreement. Hence, we also say "A is independent of B." It is important to recognize that "A independent of B" does not imply nor is implied by "B independent of A." To illustrate this, suppose that the data values in cells (3,2,1) and (3,3,1) had been reversed so that (3,2,1) is now 27 and (3,3,1) is 24. The rows are still in the same rank order but the columns are not. Hence, A is still independent of B, but independence of B from A would be violated. A second point to recognize is that we are only looking at independence for two factors at a time at this point.

For the unconditional data in Table 1, SWAT would produce the results for tests of independence shown in Table 3. As was mentioned above, SWAT actually tests all possible combinations of levels of the factors for simple independence. In the case of Factors A, B, and C with three levels each there are 3x36 = 108 possible tests for each factor. In the case of four levels for each factor there are 6x120 = 720 possible tests.

Table 3

Results of Tests of Simple Independence for Unconditional Data in the 3x3x3 Factor Matrix

A INDEPENDENT OF B AND C

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	52.0	0.481	0.500	
FAILURES:	56.0	0.519	0.500	

B INDEPENDENT OF C AND A

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	56.0	0.519	0.500	
FAILURES:	52.0	0.419	0.500	

C INDEPENDENT OF A AND B

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	66.0	0.611	0.500	
FAILURES:	42.0	0.389	0.500	

Table 4

Results of Tests of Simple Independence for Double Data in the 3x3x3 Factor Matrix

A INDEPENDENT OF B AND C

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	108.0	1.000	0.500	
FAILURES:	0.0	0.000	0.500	

B INDEPENDENT OF C AND A

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	108.0	1.000	0.500	
FAILURES:	0.0	0.000	0.500	

C INDEPENDENT OF A AND B

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	88.0	0.815	0.500	
FAILURES:	20.0	0.185	0.500	

In looking at each level of Table 3 we find that of the 108 tests of each factor there were about 50% violations in each case. The actual observed proportions were .519, .481, and .389 for Factors A, B, and C, respectively. Since under a "Random Data Model" one would expect an error proportion of .500, SWAT provides a test of the hypothesis that $p = .500$ or that the data fit the Random Data Model against the alternative that $p < .500$. In the case of this data, the results are not significant for all three factors at the .01 level. It is important to note that the normal approximation that is used for testing the hypothesis that $p = .500$ is even more of an approximation since all 108 tests in each case are clearly not independent. The practical significance of this, however, appears to be minimal (cf. Nygren, 1979). Finally, Table 4 presents the results of the simple independence tests for the Double data. As shown in the table it must be the case that there are no violations of simple independence for Factors A and B.

Table 5 indicates the additional tests of the simple independence axiom. The values in Table 5 are Kendall's Coefficients of Concordance (W) across rows or across columns at each level of the outside factor. Thus, if independence is satisfied, then the rows and columns of the data matrix in Table 1 should be like those in the Triple condition in Table 2 with all rows and columns being in the same rank order, yielding W values equal to 1.0. This is clearly not always the case with real data. For the Double condition data, however, it must be the case that "A of B", "A of C", "B of A", and "B of C" coefficient values are all 1.0. To the extent that some of the W values are near zero we may have either (1) nonindependence of factors, (2) degenerate levels(s) of some factor or factors or (3) irrelevance of a factor. The last possibility is particularly interesting from an empirical standpoint. Suppose that one were to find the W values of 1.0 in Table 5 for two of the factors when simple independence is tested. One might be tempted to conclude that no simple conjoint rule can be applied to the data. However, violations of independence would be restricted to Factor C. Violations may have occurred here because the individual did not differentiate among the levels of Factor C. In this case, the subject's judgments or rankings of alternatives would be based on the combination of only the two independent Factors A and B.

As was described above an attempt was made to investigate violations of the axioms under several different conditions. In particular, the degree to which simple independence was satisfied was varied. Table 6 presents the results of the extensive search for violations of simple independence for each of the four types of data matrices for the 3x3x3 and 4x4x4 designs. Several important points can be made from the reported mean proportions in this table.

First, as expected the "Failures" column indicates that the observed proportions of violations of the simple independence axiom is very close to what one expects for random data -- namely a value of .500. These values indicate that the random number generator used in the study appears to be very good. It is interesting to note, however, that the proportion of failures in the Single and Double conditions for the remaining random factors are slightly less than .500. The remaining columns in Table 6 divide the failures into two types, <u>dominant</u> and <u>tradeoff</u>. Recall from Equation 2 that in simple independence we are comparing two levels of one factor (a_1 and b_1) at two combinations of the second and third factors ($[a_2,a_3]$ and $[b_2,b_3]$). A violation occurs when $a_1 > a_2$ for one combination and $a_1 < a_2$ in the other. We then define a <u>dominant failure</u> as one for which <u>both</u> the a_2 and a_3 levels in the $[a_2,a_3]$ combination dominate or are dominated by their respective counterparts in $[b_2,b_3]$. <u>Tradeoff failures</u> are defined as those that occur between stimuli where one stimulus does not dominate the other on both of the combined factors. For example, (1,1,1) > (2,1,1) but (1,2,2) < (2,2,2) would result in a dominant violation since for the two outside factors (1,1) is dominated by (2,2). The test (1,2,1) > (3,2,1) but (1,1,3) < (3,1,3) is a tradeoff violation since (2,1) does not dominate and is not dominated by (1,3).

From Table 6 it is clear that under random data assumptions one should expect the proportions of dominant errors to be .375 for a 3x3x3 design and .350 for a 4x4x4 design. These proportions may prove to be very valuable in evaluating the fit of an additive model in an empirical situation. First, these values give a benchmark to indicate whether or not a individual subject's data is being fit significantly better than would be expected by chance. Second, the conditional proportions of failures indicate some interesting results. These proportions are simply the conditional proportions, p[dominant failure | failure] and p[tradeoff failure | failure]. Although the unconditional proportions of failures seem to decrease as the number of factors satisfying simple independence goes from zero to one and to two, the conditional values of p[dominant | failure] and p[tradeoff | failure] remain constant at .750 and .250 for the 3x3x3 design and at .700 and .300 for the 4x4x4 design respectively.

These latter results suggest a means of testing between two possible sources of violations in an individual subject's data. It seems reasonable that violations may occur either because (1) the subject ignores the factor(s) completely or (2) the subject uses the factor but in a non-independent way. It seems reasonable that in the former case when the factor is ignored the data would act like random data with the proportions of dominant and tradeoff errors being similar to those presented in Table 6. In the latter case, however, if the individual is in fact attending to the factor then an overall reduction in failures would be expected, at least to a moderate degree. The important aspect here is that this reduction should show up to a greater extent in the dominant tests. It is clear that regardless of the combination rule used by the individual, comparisons among stimuli that dominate others on all factors are easier to make and are more likely to satisfy the independence axiom. This suggests an important possible means of examining individual subjects' data in more detail.

Table 7 summarizes the results of the Kendall's Coefficients of Concordance values that were found in each of the 1000 data sets in each of the four conditions. The values in the table are the means based on the 1000 data sets in each case. These values are also useful in providing a benchmark from which we can compare empirical results. It is important to note that in no case are these mean coefficients close to zero. In particular, these means increase dramatically for non-independent factors if one or more of the remaining factors do satisfy independence. Since these values are means, it is clear that an impressively large W value could occur in any given case fairly easily by chance alone. Hence, it is important to not use these observed W values exclusively but in conjunction with the information found in Table 6.

Table 5
Coefficients of Concordance for Simple Independence from Unconditional Data in the 3x3x3 Factor Matrix

INDEPENDENCE: FACTOR C IS THE OUTSIDE FACTOR.

	1	2	3
B OF A	.333	.778	.000
A OF B	.111	.444	.111

INDEPENDENCE: FACTOR A IS THE OUTSIDE FACTOR.

	1	2	3
C OF B	.778	.111	.778
B OF C	.111	.444	.778

INDEPENDENCE: FACTOR B IS THE OUTSIDE FACTOR.

	1	2	3
A OF C	.778	.778	.778
C OF A	.111	.778	.778

Table 6

Observed Error Proportions for the Simple Independence Axiom for 3x3x3 and 4x4x4 Designs

Analysis	Test: Factor	Failures 3	Failures 4	Dominant Failures: Uncond'l 3	Dominant Failures: Uncond'l 4	Dominant Failures: Cond'l 3	Dominant Failures: Cond'l 4	Tradeoff Failures: Uncond'l 3	Tradeoff Failures: Uncond'l 4	Tradeoff Failures: Cond'l 3	Tradeoff Failures: Cond'l 4
	A of B,C	.500	.500	.374	.350	.749	.700	.126	.150	.251	.300
Uncond	B of A,C	.499	.501	.374	.350	.750	.700	.125	.150	.250	.300
	C of A,B	.498	.501	.374	.350	.751	.700	.124	.150	.249	.300
	(Expected)	.500	.500	.375	.350	.750	.700	.125	.150	.250	.300
	A of B,C	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Single	B of A,C	.453	.468	.330	.317	.728	.678	.123	.151	.272	.322
	C of A,B	.457	.468	.332	.317	.728	.678	.124	.151	.272	.322
	A of B,C	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Double	B of A,C	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	C of A,B	.384	.392	.288	.274	.750	.698	.096	.118	.250	.302
	A of B,C	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Triple	B of A,C	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	C of A,B	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

Note: Each mean proportion is based on 108,000 tests (108 tests for each of 1000 data sets) or 720,000 tests for the 3x3x3 and 4x4x4 designs respectively.

Table 7

Mean Kendall's Coefficient of Concordance Values for Simple Independence in the 3x3x3 and 4x4x4 Designs

Analysis	Design	A of B	A of C	B of A	B of C	C of A	C of B
Uncond	3	.327	.338	.329	.338	.327	.329
Uncond	4	.252	.248	.251	.248	.249	.250
Single	3	1.000	1.000	.578	.342	.571	.338
Single	4	1.000	1.000	.537	.248	.539	.248
Double	3	1.000	1.000	1.000	1.000	.519	.571
Double	4	1.000	1.000	1.000	1.000	.557	.536
Triple	3	1.000	1.000	1.000	1.000	1.000	1.000
Triple	4	1.000	1.000	1.000	1.000	1.000	1.000

Note: Each mean value in the table is based on 1000 data sets.

Joint Independence

Table 8 presents similar results for joint independence for the unconditional data. The W values are all moderately low as one might expect. These coefficients are somewhat difficult to interpret in and of themselves. Hence, SWAT again presents a summary of the actual tests of joint independence in the data. To understand the implications of and the differences between the tests of simple independence (Table 3) and joint independence (Table 8), it is important to follow how the W-values were computed. First, we will illustrate simple independence with the value of $W = .333$ from Table 3. This value was obtained from the check of independence for B of A at level C_1. It was obtained by comparing the rank orders of the following three sets (a_1-a_3) of three numbers (b_1-b_3):

(1) 21.0, 22.0, 14.0

(2) 13.0, 27.0, 2.0

(3) 24.0, 8.0, 9.0

In a comparable manner independence for A of B at level c_1 where $W = .111$ was obtained by comparing the rank orders of the three sets (b_1-b_3) of three numbers (a_1-a_3):

(1) 21.0, 13.0, 24.0

(2) 22.0, 27.0, 8.0

(3) 14.0, 2.0, 9.0

The joint independence value of $W = .346$ from Table 8 for "C of AB" was obtained by comparing the rank orders of the following nine sets $([a_1,b_1],[a_1,b_2],\ldots,[a_3,b_3])$ of three numbers (c_1-c_3):

(1) 21.0, 11.0, 15.0

(2) 22.0, 3.0, 12.0

(3) 14.0, 10.0, 25.0

.

.

.

(9) 9.0, 17.0, 18.0

Finally, $W = .578$ for "AB of C" was found from the ranks of three sets of nine numbers:

(1) 21.0, 13.0, 24.0, 22.0, 27.0, 8.0, 14.0, 2.0, 9.0

(2) 11.0, 16.0, 23.0, 3.0, 7.0, 4.0, 10.0, 1.0, 17.0

(3) 15.0, 5.0, 26.0, 12.0, 20.0, 19.0, 25.0, 6.0, 18.0

In a manner comparable to that discussed above for the simple independence axiom, mean proportions of violations were computed for the 1000 data sets in each of the four independence conditions and each of the two stimulus designs with the joint independence axiom. The results of these tests are summarized in Table 9. The "Failures" column then indicates the mean error proportions for tests of joint independence when either zero, one, two or all three factors satisfy simple independence. Several important results are shown in this column. First, as might be expected for random data the probability of observing a violation of joint independence is .500. When even one factor satisfies simple independence, however, the expected proportion of violations drops to .245 for tests involving the one factor satisfying simple independence. It is also interesting to note that the error proportions again appear to be about the same for either the 3x3x3 or 4x4x4 design. Finally, the Triple data indicate an important finding that is often overlooked when examining real data. The proportions of violations in the Triple data are about .05 despite the fact that simple independence is satisfied perfectly for all three factors. If joint independence holds for all pairs of factors, then independence holds for each factor. The converse is not true, however. Simple independence does not imply joint independence.

The tests of joint independence were divided as before into dominant and tradeoff tests. Dominant tests are defined as those for which the levels of the joint factors were both strictly dominant in one of the stimulus pairs. Tradeoff tests are defined as those for which the levels of the joint factors are strictly dominant in one direction for one factor and in the opposite direction for the other factor. Finally, we define weakly dominant tests as those for which there is equality of levels on one of the joint factors and dominance on the other. Thus we can have weak dominance on the first or the second factor of the pair of joint factors. An example of a violation of a strict dominance test, a weak dominance test on Factor A, a weak dominance test on Factor B, and a tradeoff test for joint independence of A and B from C are shown below:

Strict dominance:	(2,2,2) > (1,1,2) but (2,2,3) < (1,1,3)
Weak dominance on B:	(2,2,2) > (2,1,2) but (2,2,3) < (2,1,3)
Weak dominance on A:	(2,2,2) > (1,2,2) but (2,2,3) < (1,2,3)
Tradeoff:	(2,1,2) > (1,2,2) but (2,1,3) < (1,2,3)

Table 9 presents a breakdown of the violations of joint independence into the four categories illustrated above. These mean proportions are clearly stable for the unconditional data matrices. When simple independence is satisfied by one or more factors, however, it is possible to further differentiate among the tests. For the Single data, when simple independence is satisfied by Factor A, tests of joint independence of A and B from C and of C and A from B result in fewer violations. The weakly dominant tests indicate that failures cannot occur in the A,B of C and C,A of B tests if simple independence in Factor A holds. When simple independence holds for Factors A and B, this implies that all violations of joint independence for A and B of C must be tradeoff violations. Finally, when simple independence holds for all three factors then all violations for A and B of C, B and C of A, and for C and A of B are tradeoff violations.

The mean Kendall's coefficient of concordance values for the tests of joint independence are presented in Table 10. Since these W values are based on more or extensive rankings than are the values in Table 7, they tend to be closer to zero. However, as simple independence is satisfied in one or more factors, these W values again increase rather dramatically. Observed values from empirical data can be impressively high, even when simple independence holds in only one factor. The values in Table 10 can be used for appropriate comparison purposes.

Table 8

Results of Tests of Joint Independence for Unconditional Data in the 3x3x3 Factor Matrix

A X B INDEPENDENT OF C

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	68.0	0.630	0.500	
FAILURES:	40.0	0.370	0.500	

JOINT INDEPENDENCE: FACTOR C IS THE OUTSIDE FACTOR.

A, B OF C	W = 0.578
C OF A, B	W = 0.346

B X C INDEPENDENT OF A

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	60.0	0.556	0.500	
FAILURES:	48.0	0.444	0.500	

JOINT INDEPENDENCE: FACTOR A IS THE OUTSIDE FACTOR.

B, C OF A	W = 0.437
A OF B, C	W = 0.086

C X A INDEPENDENT OF B

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	56.0	0.519	0.500	
FAILURES:	59.0	0.481	0.500	

JOINT INDEPENDENCE: FACTOR B IS THE OUTSIDE FACTOR.

C, A OF B	W = 0.374
B OF C, A	W = 0.160

Table 9

Observed Error Proportions for the Joint Independence Axiom for 3x3x3 and 4x4x4 Designs

Analysis	Test:	Failures		Dominant Failures		Tradeoff Failures		Weak Failures 1st Factor		Weak Failures 2nd Factor	
	Factors	3	4	3	4	3	4	3	4	3	4
Uncond	A,B of C	.495	.500	.123	.150	.123	.150	.124	.100	.124	.100
	B,C of A	.500	.502	.124	.151	.125	.150	.125	.100	.126	.099
	C,A of B	.503	.501	.125	.151	.126	.150	.125	.099	.127	.100
	(Expected)	.500	.500	.125	.150	.125	.150	.125	.100	.125	.100
Single	A,B of C	.245	.233	.061	.067	.061	.066	.000	.000	.123	.100
	B,C of A	.332	.335	.082	.100	.082	.101	.083	.068	.084	.066
	C,A of B	.243	.234	.058	.066	.060	.067	.124	.100	.000	.000
Double	A,B of C	.079	.076	.000	.000	.079	.076	.000	.000	.000	.000
	B,C of A	.190	.183	.048	.052	.048	.054	.000	.000	.094	.077
	C,A of B	.140	.118	.027	.025	.028	.026	.085	.067	.000	.000
Triple	A,B of C	.053	.047	.000	.000	.053	.047	.000	.000	.000	.000
	B,C of A	.075	.071	.000	.000	.075	.071	.000	.000	.000	.000
	C,A of B	.046	.040	.000	.000	.046	.040	.000	.000	.000	.000

Note: Each mean proportion is based on 108,000 tests (108 tests for each of 1000 data sets) or 720,000 tests for the 3x3x3 and 4x4x4 designs respectively.

Table 10

Mean Kendall's Coefficient of Concordance Values for Joint Independence in the 3x3x3 and 4x4x4 Designs

Analysis	Design	A of BC	B of CA	C of AB	BC of A	CA of B	AB of C
Uncond	3	.110	.113	.114	.326	.279	.415
Uncond	4	.063	.061	.062	.247	.249	.250
Single	3	1.000	.202	.196	.618	.757	.753
Single	4	1.000	.131	.133	.577	.760	.761
Double	3	1.000	1.000	.341	.831	.898	.950
Double	4	1.000	1.000	.301	.839	.925	.956
Triple	3	1.000	1.000	1.000	1.000	1.000	1.000
Triple	4	1.000	1.000	1.000	1.000	1.000	1.000

Note: Each mean value in the table is based on 1000 data sets.

Double Cancellation and Distributrive Cancellation

Tables 11 and 12 present the summaries of the results obtained from the analyses of the double and distributive cancellation axioms. Several points are of interest here. It is important to note that both of these cancellation axioms have several antecedent conditions that need to be met before a test is possible. For double cancellation there are two such antecedent conditions and for distributive cancellation there are three. Hence, both of these tables first present the proportion of all tests that were actually possible in the data; that is, tests that met the antecedent conditions. For double cancellation this is not a trivial matter in practice, since as Table 11 illustrates, for random data only one-third of the tests can be expected to meet the antecedent conditions.

As more order is present in the data, the proportion of possible tests increases. It appears from Table 11 that if two or all three factors satisfy simple independence, then about two-thirds of all tests are possible. Hence, these proportions suggest that the number of possible tests in the data may be as important as the number of violations of these tests for the double cancellation axiom. Several points are suggested here. First, the proportion of possible tests may upon closer examination in further research allow for a distinction between violations due to randomness and violations due to a non-additive model. Second, it is clear that even if simple independence holds for all three factors, not all tests of double cancellation will be possible. This may seem somewhat counterintuitive at first since both axioms are necessary for an additive model. However, the two axioms are examining properties of the data that are, though clearly related, somewhat unique.

The relationship between simple independence and double cancellation is seen more clearly in the proportions of failures in Table 11. The research presented here clearly demonstates the usefulness of the error theory approach. When simple independence is satisfied by one of the factors A, the proportion of violations of double cancellation drops greatly in for tests in both the AxB and AxC planes. When simple independence is satisfied by all three factors the proportions of conditional violations (that is, a violation given a test is possible) drops to about 10% to 15%. Hence, the researcher using conjoint scaling methodology should not be overly optomistic about an additive model when conditional error rates for double cancellation are around ten to fifteen percent. There values can be obtained for many nonadditive data sets as long as simple independence is not violated by one of the three factors.

The last axiom, distributive cancellation, is examined in Table 12. It is clear from the results summarized in this table that the distributive cancellation axiom is not a useful diagnostic tool for the conjoint scaling researcher. The axiom is a very weak one. First, it is interesting and somewhat surprising that for even random data the proportion of tests that meet the antecedent conditions is very high in all cases, exceeding 90%. Second, even for random data only about 25% of the tests will result in violations. When independence is satisfied by one or more of the factors, the proportion of violations is reduced considerably. These error proportions are, in fact, so small that the data almost look as though they are nearly perfectly satisfied. The error proportions are in the 1% to 2% range when two or three factors satisfy simple independence. These results are also very important for the researcher using conjoint scaling methodology. It is clear that a conclusion of additivity based on error rates in the 1% to 5% range for distributive cancellation could be quite erroneous. One could easily get such seemingly impressive results when the model is not at all additive. In fact, one could easily get such results when only one factor satisfies simple independence.

Table 11

Observed Error Proportions for the Double Cancellation Axiom for 3x3x3 and 4x4x4 Designs

Analysis	Test: Factors	Possible Tests 3	Possible Tests 4	Failures 3	Failures 4	Conditional Failures 3	Conditional Failures 4
	AxB plane	.356	.331	.269	.247	.757	.748
Uncond	BxC plane	.325	.332	.249	.248	.766	.747
	CxA place	.341	.330	.253	.247	.743	.748
	(Expected)	.333	.333	.250	.250	.750	.750
	AxB plane	.475	.509	.068	.049	.144	.097
Single	BxC plane	.326	.339	.250	.250	.768	.750
	CxA plane	.490	.509	.052	.051	.106	.100
	AxB plane	.623	.643	.095	.064	.152	.100
Double	BxC plane	.485	.509	.065	.050	.135	.098
	CxA plane	.639	.718	.021	.014	.032	.020
	AxB plane	.654	.654	.101	.053	.155	.081
Triple	BxC plane	.642	.639	.097	.063	.154	.099
	CxA plane	.790	.837	.037	.018	.047	.022

Note: Mean proportions in the table are based on 3000 tests (3 tests for 1000 data sets) and 64000 tests for the 3x3x3 and 4x4x4 designs respectively.

Table 12

Observed Error Proportions for the Distributive Cancellation Axiom for the 3x3x3 and 4x4x4 Designs

Analysis	Test: Outside Factor	Possible Tests 3	Possible Tests 4	Failures 3	Failures 4	Conditional Failures 3	Conditional Failures 4
	A outside	.971	.971	.254	.255	.261	.262
Uncond	B outside	.971	.972	.257	.255	.257	.262
	C outside	.971	.971	.249	.255	.265	.263
	A outside	.996	.996	.044	.053	.044	.053
Single	B outside	.932	.922	.069	.053	.073	.057
	C outside	.930	.922	.068	.053	.074	.058
	A outside	.989	.984	.012	.012	.012	.012
Double	B outside	.956	.930	.021	.018	.022	.020
	C outside	.907	.900	.030	.018	.033	.020
	A outside	.984	.979	.005	.004	.005	.004
Triple	B outside	.945	.918	.008	.006	.008	.005
	C outside	.923	.910	.010	.005	.010	.006

Note: Mean proportions in the table are based on 243,000 tests (243 tests for 1000 data sets) and 7,776,000 tests for the 3x3x3 and 4x4x4 designs respectively.

V. CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

Subjective assessment techniques for scaling the joint effects of several psychological variables have been of interest to social and behavioral scientists for years. In particular, models suggesting that the joint effect is a function of an additive combination rule have been suggested in many applications. In practice, the scaling has been applied to a limited number of interesting situations, however, because the properties of additive conjoint measurement have not been well understood (cf., Nygren, 1980; Wallsten, 1976). This research project has dealt with one aspect of these theoretical foundations, the violations of the properties in the axiom system associated with additive conjoint measurement. It is felt that the results presented in this paper will provide useful data by which the applied researcher can evaluate the fit of an additive model to his or her own data sets. However, a number of additional studies are clearly needed if additive conjoint measurement is to become a powerful scaling methodology. These areas are listed below.

1. Examination of other conditional

errors. This project was limited to an examination of what happens to violations of the conjoint measurement axioms when simple independence is satisfied by none, one, two, or all three of the factors. The results are certainly encouraging with respect to being able to set expected violation proportions. It seems reasonable to suggest that other axioms (e.g., double cancellation) serve as the conditional axiom for evaluating expected error rates. Related to this is an issue that was not touched upon in this project. Here we started with random data and added order to it systematically by satisfying simple independence in one to three factors. Another approach might be to work in somewhat of an opposite direction. We might start with a perfectly additive data set and systematically add random error to it. We then would test for violations of the axioms. What this would do for the applied researcher is to allow him or her to determine expected violations of the axioms for different amounts of error in the subjects' data. For example, if one knew that a particular conjoint scaling task was very demanding of a subject and could estimate (from previous research) the degree to which error can be expected in a subject's judgments, then the researcher could compare violations of the axioms with the appropriate values expected under these conditions. For a demanding task one might be expected to allow for more violations when evaluating the fit of an additive model.

2. <u>Examination of goodness-of-fit of scaling solutions</u>. Originally, the project also included as an objective the evaluation of the fit of an additive scaling solution to the generated data sets used in this study. However, it soon became apparent that the cost in terms of computer time for evaluating several nonmetric computer algorithms (MONANOVA and SWAT) would have been prohibitive for this project. Hence, this aspect of the project was abandoned. It is, however, as important as the testing of the axioms that was done here for several reasons. First, the actual scaling solutions for data sets that fit simple independence in zero to three factors may reveal other aspects of additive models that are not readily observed in the tests of the axioms. Second, since virtually all applied researchers are interested in obtaining additive scaling solutions for their data sets, it would be extremely useful to know how good the "goodness-of-fit" measure need be in the scaling solution to support an additive model. A next step in this project sequence would be to parallel the procedure used with the axiom testing portion of SWAT with an analysis on the

scaling algorithm in SWAT.

3. <u>Comparison of different scaling algorithms</u>. Once a researcher has found evidence supporting an additve model in his data (based on the axiom tests in SWAT), he or she is still able to choose from among several different scaling procedures. Unfortunately, very little comparative data is known about the algorithms used in these programs under different conditions. For example, it is not known whether the algoithm in SWAT or the one in MONANOVA might be the better to use when error is present in the subjects' data or when there are missing data. Clearly, a systematic study comparing the algorithms in the several different additive scaling programs would be very beneficial to the applied researcher. It is entirely possible that one algorithm may be more robust in some conditions but not in others. Many studies of this nature have been done in the area of multidimensional scaling. Comparable quality studies are needed in conjoint scaling.

REFERENCES

Arbuckle, J., and Larimer, J. The number of two-way tables satisfying certain additivity axioms. Journal of Mathematical Psychology, 1976, 13, 89-100.

Emery, D.R., and Barron, F. H. Axiomatic and numerical conjoint measurement: An evaluation of diagnostic efficacy. Psychometrika, 1979, 44, 195-210.

Green, P.E. and Rao, V. Conjoint measurement for quantifying judgmental data. Journal of Marketing Research, 1971, 8, 355-363.

Green, P.E. and Srinivasan, V. Conjoint analysis in consumer research: Issues and outlook. Journal of Consumer Research, 1978, 5, 103-123.

Holt, J.O. and Wallsten, T.S. A user's manual for CONJOINT: A computer program for evaluating certain conjoint-measurement axioms. Technical Report No. 42, University of North Carolina, L. L. Thurstone Psychometric Laboratory, October, 1974.

Johnson, R.M. Pairwise nonmetric multidimensional scaling. *Psychometrika*, 1973, *38*, 11-18.

Krantz, D.H., Luce, R.D., Suppes, P., and Tversky, A. *Foundations of measurement*, *Vol. 1*. New York: Academic Press, 1971.

Krantz, D.H., and Tversky, A. Conjoint measurement analysis of composition rules in psychology. *Psychological Review*, 1971, *78*, 151-169.

Kruskal, J.B. Multidimensional scaling by optimizing goodness-of-fit to a nonmetric hypothesis. *Psychometrika*, 1964, *29*, 1-27.

Kruskal, J.B. Analysis of factorial experiments by estimating monotone transformations of the data. *Journal of the Royal Statistical Society, Series B*, 1965, *27*, 251-263.

Luce, R.D. and Tukey, J.W. Simultaneous conjoint measurement: A new type of fundamental measurement, *Journal of Mathematical Psychology*, 1964, *1*, 1-27.

McClelland, G. A note on Arbuckle and Larimer, "The Number of Two-way Tables Satisfying Certain Additivity Axioms." *Journal of Mathematical Psychology*, 1977, *14*, 292-295.

Nygren, T.E. A theoretical framework for testing the additive difference model for dissimilarities data: Representing gambles as multidimensional stimuli. Journal of Mathematical Psychology, 1979, 20, 53-77.

Nygren, T.E. Limitations of additive conjoint scaling procedures: Detecting additivity when additivity is known to be violated. Applied Psychological Measurement, 1980, 4, 367-383.

Nygren, T. E. SWAT: A User's Guide. Unpublished manuscript, 1982.

Nygren, T. E. Conjoint Measurement and Conjoint Scaling: A User's Guide. AFAMRL Technical Report No. TR-82-22, April, 1982.

Srinivasan, V. and Shocker, A.D. Linear programming techniques for multidimensional analsis of preferences. Psychometrika, 1973, 38, 337-369.

Srinivasan, V. and Shocker, A.D. Estimating the weights for multiple attributes in a composite criterion using pairwise judgments. Psychometrika, 1973, 38, 473-493.

Takane, Y., Young, F. W., and de Leeuw, J. An individual differences additive model: An alternating least squares method with optimal scaling features. Psychometrika, 1980, 45, 183-210.

Tversky, A. A general theory of polynomial conjoint measurement. Journal of Mathematical Psychology, 1967, 4, 1-20.

Ullrich, J.R. and Cummins, D.E. PCJM: A program for conjoint measurement analysis of polynomial composition rules. Behavioral Science, 1973, 18, 226-227.

Wallsten, T.S. Using conjoint measurement models to investigate a theory about probabilistic information processing. Journal of Mathematical Psychology, 1976, 14, 144-185.

Young, F.W. A model for polynomial conjoint analysis algorithms. In R. Shepard, A. K. Romney, and S. Nerlove (Eds.), Multidimensional scaling: Theory and applications in the behavioral sciences, Vol. 1. New York: Seminar Press, 1972, Pp. 69-104.

APPENDIX 1

```
 SSSSS    W       W     AAA     TTTTTTT
S     S   W       W    A   A       T
S         W       W   A     A      T       ...
 S        W       W   A     A      T       ...
   S      W   W   W   AAAAAAA      T       ...
     S    W  W W  W   A     A      T       ...
      S   W W   W W   A     A      T       ...
S     S   WW     WW   A     A      T
 SSSSS    W       W   A     A      T


                                           ...
U   U    SSS    EEEEE   RRRR     SSS       ...
U   U   S   S   E       R   R   S   S   ...
U   U    S      EEEE    RRRR     S
U   U      S    EEEE    R R        S
U   U   S   S   E       R  R    S   S
 UUU     SSS    EEEEE   R   R    SSS


 GGG     U   U   IIIII   DDDD    EEEEE
G   G    U   U     I     D   D   E
G        U   U     I     D   D   EEEE
G GGG    U   U     I     D   D   EEEE
G   G    U   U     I     D   D   E
 GGG      UUU    IIIII   DDDD    EEEEE
```

THOMAS E. NYGREN
DEPARTMENT OF PSYCHOLOGY
OHIO STATE UNIVERSITY
404C W. 17TH AVENUE
COLUMBUS, OHIO 43210

A USER'S GUIDE TO A COMBINED CONJOINT TESTING AND SCALING PROGRAM. VERSION 2.0.
APRIL, 1983.

"SWAT" is a computer program written in Fortran IV that can be used to test for violations of the axioms for conjoint measurement proposed by Krantz and Tversky (1971). In addition, the program will also provide an additive scaling solution based on the data. SWAT is a combination of what the author believes to be the most useful parts of several separate computer programs. First, SWAT provides some of the same information as does Wallsten's (1974) CONJOINT program for testing the conjoint measurement axioms. However, SWAT provides a more detailed analysis of violations of these axioms, especially for the critical axioms of simple independence and joint independence. In addition, SWAT is written in Fortran, whereas CONJOINT is written in PL/1, a language that may not be used at some computer installations.

SWAT also encompasses much of another axiom testing program for conjoint measurement. It employes some of the same algorithm used by Ullrich and Cummins (1973) in their PCJM2 program for examining independence, joint independence, double cancellation, distributive cancellation, and dual-distributive cancellation. SWAT, however, makes some very important corrections to logical and theoretical errors made by their PCJM2 analysis of the conjoint measurement axioms.

Finally, SWAT employs a modification of the algorithm for conjoint scaling first suggested by Johnson (1973). This simple, yet very useful, nonmetric regression procedure has been incorporated into SWAT and has been generalized to be more useful for applied research.

The SWAT program has been written with additional expansion and generalization in mind. A new extended version of the program, SWAT2, is currently being written. SWAT contains several parameters and features of various subroutines that will be available in SWAT2. These features are ignored by SWAT and have no effect on its algorithms or output. Some of these features will be obvious to the trained Fortran programmer. However, these parameters and related features should not be used in SWAT, since (1) they have not been completely checked for accuracy, (2) no documentation is currently available for their use, (3) use of these features may affect the validity of SWAT results, and (4) several of the features will only be useful with applications of theoretical developments currently being studied by the author.

An effort has been made to find all typographical errors and inaccuracies in this manual. Nevertheless, some minor problems may still exist. If inaccuracies are found, please report them to the author.

S N A T

```
************************************************************
*                                                          *
*  To call this program for the source deck form from      *
*  the tape "CDSCAL" or some comparable tape or disk       *
*  unit, use the following jcl cards:                      *
*                                                          *
*  1)  your id card        ,                               *
*  2)  //  TIME=2,REGION=300K                              *
*  3)  //  EXEC FORTRUN,TIME.GO=2,REGION.GO=300K           *
*  4)  //FORT.SYSIN DD UNIT=TAPE9,VOL=SER=CDSCAL,          *
*  5)  //  DISP=(OLD,PASS),DSN=SNAT.VER1,                  *
*  6)  //  LABEL=(8,SL),                                   *
*  7)  //  DCB=(RECFM=FB,LRECL=80,BLKSIZE=1600)            *
*  8)  //GO.SYSIN DD *                                     *
*                                                          *
*  9)  Input deck as described below (control and          *
*      data cards go here.)                                *
*                                                          *
* 10)  /*                                                  *
* 11)  //                                                  *
*                                                          *
* NOTE:  FORTRUN is a proc specific to the computer        *
* system at The Ohio State University. Other instal-       *
* lations may require a substitute name on Statement 3.    *
* For example, FORTHCLG may be used on IBM machines.       *
*                                                          *
*                                                          *
*                                                          *
************************************************************
```

S W A T

```
*************************************************************
*                                                           *
*        I n p u t   D e c k   A r r a n g e m e n t        *
*                                                           *
*************************************************************
```

Card(s) A. (jcl cards- see above cards 1 through 8.)

Card B. Initial parameter values card.
This card is mandatory.

Col.	Parameter	Meaning
2- 4	IAX	= YES, if the axiom testing procedure is to be done on the data.
6- 8	ICON	= YES, if a conjoint scaling analysis is to be done on the data.
12	NF	number of factors; maximum is 5 for SWAT.
16	DIM1	number of levels of the first factor; maximum is 5 for SWAT.
20	DIM2	number of levels of the second factor; maximum is 5 for SWAT.
24	DIM3	number of levels of the third factor; maximum is 5 for SWAT.
28	DIM4	number of levels of the fourth factor; maximum is 5 for SWAT.
32	DIM5	number of levels of the fifth factor; maximum is 5 for SWAT.
36	NBLKS	number of blocks or trade-off matrices present in the data; max=3 for Version 1, max=5 for Version 2; the maximum number of stimuli in each block is 125 for either version.
39-40	NREP	number of data matrices (i.e., subjects or

			to be independently rescaled. The maximum is 30 for SWAT.
42-44	FLAG	= YES,	if data consist of more than one observation per cell. Otherwise, the program expects only one observation per cell.
47-48	INTYP		If INTYP equals -1 or -2, it indicates one data point per cell.
		= -1,	if data are in a random or non-natural order, one observation per card.
		= -2,	if the data are in the natural order, strung out or one per card.
			If INTYP equals 1, 2, 3 or 4, it indicates multiple observations per cell.
		= 1,	if data are in a random or non-natural order, one replication per card.
		= 2,	if data are in the natural order with one replication per card.
		= 3,	if data are in a random or non-natural order, all replications per card.
		= 4,	if data are in the natural order with all replications on a card.
			If INTYP equals 1 or 3, the number of replications need not be the same in each in each cell; if equal to 2 or 4, the number of replications is assumed to be equal for all cells.
49-56	EMPTY		a real-valued number indicating the cutoff for data to be treated as missing; all observations equal to or less than the value of EMPTY will be ignored.
58-60	OVRD	= YES,	if the data for all subjects are to be averaged regardless of how well the sets of judgments are correlate with one another.
64	JUNIT	= 0,	if input data values are on punched cards.
		= N,	if input data values are on logical unit number 'N'.

67-68	NCARD	number of title or description cards used; maximum is 99 for SWAT.

Card C. Initial parameter values for testing the axioms. This card is present only if IAX = YES; otherwise skip to Card D.

Col.	Parameter	Meaning
2- 4	AXTEST(1) =	YES, if simple Independence among the factors is to be tested.
6- 8	AXTEST(2) =	YES, if Double Cancellation among the factors is to be tested.
10-12	AXTEST(3) =	YES, if Joint Independence among the factors is to be tested.
14-16	AXTEST(4) =	YES, if Distributive Cancellation among the factors is to be tested.
18-20	AXTEST(5) =	YES, if Dual-Distributive Cancellation the factors is to be tested.
22-24	PRINT =	0, if none of the violations of the axioms are to be listed. That is, the user has the option of having the SWAT program list all or part of the set of violations of each axiom. If PRINT = 0 is specified, the violations will not be printed. The maximum value of PRINT is 999 in SWAT.
	=	N, if N violations of each axiom are to be printed. The user is cautioned to choose a moderate value of N since an extensive number of printed lines could result.
26-28	SUPRS =	YES, if the printing of the matrix of cell violations is to be suppressed. It will not be printed for any of the axioms.

****

The parameters in columns 33-56 apply to tests of Distributive and Dual-Distributive Cancellation only. For both of these axioms, one factor is considered the "outside" factor. For example, for the Distributive Cancellation axiom we could have the models:

(A + B) x C, where C is the outside factor;
(A + C) x B, where B is the outside factor;
(B + C) x A, where A is the outside factor.

****

30-32	DISTLV(1)	= YES, if Distributive Cancellation with factor A as the outside factor is to be tested.
34-36	DISTLV(2)	= YES, if Distributive Cancellation with factor B as the outside factor is to be tested.
38-40	DISTLV(3)	= YES, if Distributive Cancellation with factor C as the outside factor is to be tested.
42-44	DDSTLV(1)	= YES, if Dual-Distributive Cancellation with factor A as the outside factor is to be tested.
46-48	DDSTLV(2)	= YES, if Dual-Distributive Cancellation with factor B as the outside factor is to be tested.
54-56	DDSTLV(3)	= YES, if Dual-Distributive Cancellation with factor C as the outside factor is to be tested.

Card D. Initial parameter values for conjoint scaling. This card is present only if the parameter ICON = YES.

Col.	Parameter	Meaning
3- 4	ITELIM	number of iterations allowed to reach the optimal scaling criterion. (The default value is the maximum of 80.)
6- 8	IWT = YES,	weighting of the factors is desired.
10-12	ITIES = YES,	if ties in the data are to be left as ties in the scaling solution. Otherwise, if ties are not to be forced in the scaling solution, SWAT will

		break ties as necessary to improve the fit of the scaling solution.
14-16	LABEL = YES,	if labels describing the levels of the factors are provided by the user. Any eight character description can be used for each label. If no labels are provided by the user, the levels will be numbered from '1' to 'N', where N is the total number of levels of all of the factors.
18-20	NPUN = YES,	if the final scale values for the N factor levels and for the final scaling solution will be punched on cards.
22-24	LASTIT = YES,	if SWAT is to use the scaling solution from the last iteration. If LASTIT is not set to YES, SWAT will use the solution from the iteration with the lowest THETA value. (THETA is the measure of badness-of-fit used in SWAT.)
26-28	NREVR = YES,	if the input data is to be reversed; that is, given values of the opposite sign. This means that small data values will result in large scale values. If NREVR is not set to YES, the data will be left as is.
30-32	IPLOT = YES,	if a ploting of the original data (x-axis) vs. the rescaled additive stimulus values (y-axis) will be drawn for each block of data (i.e., NBLKS).
33-40	IRAN	an eight digit random number to generate the initial configuration in the scaling analysis.

Card E. Criterion and start card. (Format is 2F8.4).
This card is present only if the parameter ICON = YES.

Col.	Parameter	Meaning
1- 8	CRITR	this is the improvement criterion value for stopping the iterative procedure.

		(A typical value is 0.0001.)
9-16	START	a real-valued additive constant to be added to the scale value of each stimulus in the analysis. This value is usually left as 0.0.

Card(s) F. Labels card(s).

These cards are optional and will be included only if the LABEL parameter on Card D is set to YES. Also, these cards are present only if the parameter ICON = YES. The format is (8A8). Each card contains, in order, the labels of the factor levels. There can be a maximum of nine labels per card. Each label can be up to eight characters in length. Use as many label cards as needed.

Col.	Parameter	Meaning
1- 8	VNAME(1)	label for level 1 of factor 1 (A).
9-16	VNAME(2)	label for level 2 of factor 1.
17-24	VNAME(3)	label for level 3 of factor 1.

. etc.
.
.

Card(s) G. Block identification card(s).

These cards indicate information about each block of data. A "block" is one set of judgments obtained from the factorial crossing of two or more factors. The data within a block can be compared; the data across blocks are not directly comparable.
There will be as many cards as there are blocks.

Col.	Parameter	Meaning
4	FC(b)	number of factors in this Block b.
6- 8	INVA1(b)	number of stimuli or data cells in Block b.
12	IDMA2(1,b)	the factor number for the first factor in

		Block b.
16	IDMA2(2,b)	the factor number for the second factor in Block b.
20	IDMA2(3,b)	the factor number for the third factor in Block b.

. etc.
.
.

For example, suppose that the user had a three factor design with the data being entered in three two-factor tradeoff matrices. Then for Block 1, IDMA2(1,1) might be 1, IDMA2(2,1) might be 2, and IDMA2(3,1) would be irrelevant.

Card(s) H. Title card(s). (Format is 20A4).

Use as many cards as are specified by the parameter NCARD on Card B, columns 67-68.

Card I. Format for reading in the data.
The data must be real-valued numbers. The format must and end with a parenthesis.

Card(s) J. Data cards.

All NREP data matrices will be placed here, one behind the other. The format must conform with Card H.
These cards will be different depending on the value of the parameter ITYPE.

If ITYPE = -1, then proceed as follows:
For each data card there should be four numbers on the card punched in the format specified above.

a	the level of factor A.
b	the level of factor B.
c	the level of factor C.

ENTRY the actual data value. a, b, and c are assumed to be integers; ENTRY is assumed to be real.

If ITYPE = -2, then proceed as follows:
Data should be strung out in natural order. Data can be one observation per card or can be multi-observations per card.

If ITYPE = 1, proceed as with ITYPE = -1. There should be one card for each replication of each observation. The last data card should have a = 999.

If ITYPE = 2, then proceed as follows:
Card I1. The data cards should be preceded by a Card that has the number of replications for each observation punched in columns 3-4.
The data cards should have one replication of each observation punched on them.

If ITYPE = 3, then proceed as follows:
Each data card should have the following entries punched on them:

a level of factor A.

b level of factor B.

c level of factor C.

NE number of replications of this observation.

ENTR(1) - ENTR(NE) NE actual data values.

a, b, c, and NE are assumed to be integers; ENTR is assumed to be real.

If ITYPE = 4, then proceed as when ITYPE = 2, except that all replications of each observation are on the same card. Data are assumed to be in the natural order.

Card K. End of analysis card.

A blank card to signify the end of the analysis. If

additional analyses are included, repeat cards A - J.
The blank card is the last card in the data deck.

```
**************************************************
*                                                *
*           S W A T     E X A M P L E S          *
*                                                *
**************************************************
```

The following example is an illustration of the use of SWAT to test axioms for and to scale a set of data from a 4x4x3 design. The data are for one subject with three replications of each judgment. Hence, NREP = 1 but FLAG = YES.

```
 YES YES   3   4   4   3   0   0   1   1 YES   4    0.00  NO   0  15
 YES YES YES YES  NO  20 YES YES YES YES  NO  NO  NO
  15      NO YES  NO YES YES YES65492355
  0.0010  0.0000
$L=-.10 $L=-.20 $L=-.30 $L=-.40 PL=1/8  PL=2/8  PL=3/8  PL=4/8
PW=2/8  PW=3/8  PW=4/8
EXAMPLE NO. 1.  ONE SUBJECT WITH THREE REPLICATIONS.

CONJOINT SCALING:  RISKINESS DATA.
TEST ALL AXIOMS AND PERFORM THE SCALING ANALYSIS.
1  SUBJECT.
48  STIMULI.   1X4X3X4 DESIGN.
THREE REPLICATIONS OF EACH JUDGMENT.

FACTORS ARE:
AMOUNT TO LOSE, 4 LEVELS.          -10, -20, -30, AND -40 CENTS.
PROBABILITY OF WINNING, 3 LEVELS.  2/8, 3/8, AND 4/8.
PROBABILITY OF LOSING, 4 LEVELS.   1/8, 2/8, 3/8, AND 4/8.

SCALE RANGES FROM '1' TO '100'.
STIMULI ARE IN THE NATURAL ORDER.
(3F6.0)
    3
     3     5     5
     4     5     5
     4     5     6
     9     9     9
     8     9     9
     9     9     9
    14    15    15
    15    15    15
```

15	15	15
19	19	19
19	19	19
19	19	19
9	9	9
9	9	9
6	9	9
19	19	19
18	19	19
19	19	19
52	52	51
29	29	29
29	28	29
89	89	89
38	39	39
39	39	39
15	15	16
15	14	15
14	14	15
51	52	51
29	29	29
29	29	29
92	91	91
61	51	52
46	45	45
96	96	92
95	94	94
59	59	59
19	19	19
19	19	19
19	19	19
88	89	89
39	39	89
39	39	39
94	96	95
96	93	94
59	59	59
98	99	96
97	98	96
98	97	96

The following example is an illustration of the use of SWAT to test axioms for and to scale a set of data from a 4x4x3 design. The data are for three subjects with one replication of each judgment. Hence, NREP = 3 and FLAG = YES.

```
 YES YES   3   4   4   3   0   0   1   3 YES   4    0.00  NO   0  15
 YES YES YES YES  NO  20 YES YES YES YES  NO  NO  NO
  15      NO YES  NO YES YES YES65492355
  0.0010  0.0000
$L=-.10 $L=-.20 $L=-.30 $L=-.40 PL=1/8  PL=2/8  PL=3/8  PL=4/8
PW=2/8  PW=3/8  PW=4/8
EXAMPLE NO. 2.  THREE SUBJECTS WITH ONE REPLICATION.

CONJOINT SCALING:  RISKINESS DATA.
TEST ALL AXIOMS AND PERFORM THE SCALING ANALYSIS.
3  SUBJECTS.
48  STIMULI.   1X4X3X4 DESIGN.
ONE REPLICATION OF EACH JUDGMENT.

FACTORS ARE:
AMOUNT TO LOSE, 4 LEVELS.           -10, -20, -30, AND -40 CENTS.
PROBABILITY OF WINNING, 3 LEVELS.  2/8, 3/8, AND 4/8.
PROBABILITY OF LOSING, 4 LEVELS.   1/8, 2/8, 3/8, AND 4/8.

SCALE RANGES FROM '1' TO '100'.
STIMULI ARE IN THE NATURAL ORDER.
(3F6.0)
   3
     3     5     5
     4     5     5
     4     5     6
     9     9     9
     8     9     9
     9     9     9
    14    15    15
    15    15    15
    15    15    15
    19    19    19
    19    19    19
    19    19    19
     9     9     9
     9     9     9
     6     9     9
    19    19    19
    18    19    19
```

19	19	19
52	52	51
29	29	29
29	28	29
89	89	89
38	39	39
39	39	39
15	15	16
15	14	15
14	14	15
51	52	51
29	29	29
29	29	29
92	91	91
61	51	52
46	45	45
96	96	92
95	94	94
59	59	59
19	19	19
19	19	19
19	19	19
88	89	89
39	39	89
39	39	39
94	96	95
96	93	94
59	59	59
98	99	96
97	98	96
98	97	96

The following example is an illustration of the use of SWAT to test axioms for and to scale a set of data from a 3x3x3 design. The data are for one subject with one replication of each judgment. Hence, NREP = 1 and FLAG = NO.

```
 YES YES    3   3   3   3   0   0   1   1  NO  -2    0.00 YES   0   8
 YES YES YES YES  NO  20  NO YES YES YES  NO  NO  NO
  60     NO YES  NO YES YES YES89456773
 0.00001 0.00000
   TIME1   TIME2   TIME3 EFFORT1 EFFORT2 EFFORT3 STRESS1 STRESS2
 STRESS3
EXAMPLE NO. 3.
FULL MATRIX (27 STIMULI) DATA.
CONJOINT SCALING:  SWAT
 1 AVERAGE SUBJECT.
27  STIMULI.   3X3X3 DESIGN.

FACTORS ARE TIME, EFFORT, AND STRESS.
STIMULI ARE IN THE NATURAL ORDER.
(F6.1)
   1.0
   2.0
   6.0
   3.0
  10.5
  13.0
   5.0
   8.0
  15.0
   4.0
  10.5
  14.0
   9.0
  16.0
  21.0
  12.0
  20.0
  24.0
   7.0
  17.0
  22.0
  18.5
  23.0
  26.0
  18.5
```

25.0
27.0

The following example is an illustration of the use of SWAT to test axioms for and to scale a set of data from a 3x3x3 design. The data are for two subjects with one replication of each judgment. Hence, NREP = 2 and FLAG = YES.

```
 YES YES   3   3   3   3   0   0   1   2 YES   4    0.00 YES   0   8
 YES YES YES YES  NO  20  NO YES YES YES  NO  NO  NO
  60      NO YES  NO YES YES YES89456773
 0.00001 0.00000
   TIME1   TIME2   TIME3 EFFORT1 EFFORT2 EFFORT3 STRESS1 STRESS2
 STRESS3
EXAMPLE NO. 4.   FULL MATRIX (27 STIMULI) DATA.
CONJOINT SCALING:  SWAT

 2 SUBJECTS.
27  STIMULI.   3X3X3 DESIGN.

FACTORS ARE TIME, EFFORT, AND STRESS.
STIMULI ARE IN THE NATURAL ORDER.
(2F6.1)
   2
   1.0   2.0
   2.0   3.0
   3.0   4.0
   4.0   5.0
   5.0   6.0
   6.0   7.0
   7.0   8.0
   8.0   9.0
   9.0  10.0
  10.0  11.0
  11.0  12.0
  12.0  13.0
  13.0  14.0
  14.0  15.0
  15.0  16.0
  16.0  17.0
  17.0  18.0
  18.0  19.0
  19.0  20.0
  20.0  21.0
  21.0  22.0
  22.0  23.0
  23.0  24.0
  24.0  25.0
```

25.0	26.0
26.0	27.0
27.0	28.0

The following example is an illustration of the use of SWAT to test axioms for and to scale a set of data from a 3x3x3 design. The data are for one subject with one replication of each judgment. Hence, NREP = 1 and FLAG = NO. In addition, however, the data are presented in three tradeoff matrices for three pairs of factors. Hence, NBLKS = 3 and Cards G are included.

```
 YES YES   3   3   3   3   0   0   3   1  NO  -2    0.00 YES   0   8
 YES YES  NO  NO  NO  20  NO  NO  NO  NO  NO  NO  NO
  60      NO YES  NO YES YES YES89456773
 0.00001 0.00000
   TIME1   TIME2   TIME3 EFFORT1 EFFORT2 EFFORT3 STRESS1 STRESS2
 STRESS3
   2   9   1   2
   2   9   1   3
   2   9   2   3
EXAMPLE NO. 5.
FULL MATRIX (27 STIMULI) DATA.
CONJOINT SCALING:  SWAT        TRADE-OFF MATRICES.
 1 AVERAGE SUBJECT.
27  STIMULI.   3X3X3 DESIGN.
3 BLOCKS, 9 STIMULI IN EACH BLOCK.
FACTORS ARE TIME, EFFORT, AND STRESS.
STIMULI ARE IN THE NATURAL ORDER.
(9X,F7.1)
100100000    9.0
010100000    8.0
001100000    6.0
100010000    7.0
010010000    4.0
001010000    3.0
100001000    5.0
010001000    2.0
001001000    1.0
100000100    9.0
010000100    6.0
001000100    3.0
100000010    8.0
010000010    5.0
001000010    2.0
100000001    7.0
010000001    4.0
001000001    1.0
000100100    9.0
000010100    6.0
000001100    3.0
000100010    8.0
000010010    5.0
000001010    2.0
```

000100001	7.0
000010001	4.0
000001001	1.0

The following example is an illustration of one of the random data sets used in the Nygren (1983) study. The analysis is set for SWAT to test axioms and scale the data in a 3x3x3 design.
The data are for one subject with one replication of each judgment. Hence, NREP = 1 and FLAG = NO.

```
YES YES   3   3   3   3   0   0   1   1  NO  -2    0.00 YES   0   3
YES YES YES YES  NO   0 YES YES YES YES  NO  NO  NO
 60      NO YES  NO YES  NO  NO76655659
0.00001 0.00000
  TIME1   TIME2   TIME3 EFFORT1 EFFORT2 EFFORT3 STRESS1 STRESS2
STRESS3 EXAMPLE NO.   5.  - 27  STIMULI.   3X3X3  DESIGN.   RANDOM DATA.
(76655659).  1 RANK SUBJECT.  STIMULI ARE IN THE NATURAL ORDER.  (3F7.2)
 21.00  11.00  15.00
 22.00   3.00  12.00
 14.00  10.00  25.00
 13.00  16.00   5.00
 27.00   7.00  20.00
  2.00   1.00   6.00
 24.00  23.00  26.00
  8.00   4.00  19.00
  9.00  17.00  18.00
```

The following example is an illustration of one of the random data sets used in the Nygren (1983) study. The analysis is set for SWAT to test axioms and scale the data in a 3x3x3 design. Simple independence holds for Factor A.
The data are for one subject with one replication of each judgment. Hence, NREP = 1 and FLAG = NO.

```
YES YES   3   3   3   3   0   0   1   1  NO  -2    0.00 YES   0   3
YES YES YES YES  NO   0 YES YES YES YES  NO  NO  NO
 60      NO YES  NO YES  NO  NO76655659
0.00001 0.00000
  TIME1   TIME2   TIME3 EFFORT1 EFFORT2 EFFORT3 STRESS1 STRESS2
STRESS3 EXAMPLE NO.   6.   27  STIMULI.   3X3X3  DESIGN.   RANDOM DATA.
(76655659).  1 RANK SUBJECT.  STIMULI ARE IN THE NATURAL ORDER.   (3F7.2)
  13.00  11.00   5.00
   8.00   3.00  12.00
   2.00   1.00   6.00
  21.00  16.00  15.00
  22.00   4.00  19.00
   9.00  10.00  18.00
  24.00  23.00  26.00
  27.00   7.00  20.00
  14.00  17.00  25.00
```

The following example is an illustration of one of the random data sets used in the Nygren (1983) study. The analysis is set for SWAT to test axioms and scale the data in a 3x3x3 design. Simple independence holds for Factors A and B. The data are for one subject with one replication of each judgment. Hence, NREP = 1 and FLAG = NO.

```
YES YES   3   3   3   3   0   0   1   1  NO  -2    0.00 YES   0   3
YES YES YES YES  NO   0 YES YES YES YES  NO  NO  NO
 60      NO YES  NO YES  NO  NO76655659
0.00001 0.00000
  TIME1   TIME2   TIME3 EFFORT1 EFFORT2 EFFORT3 STRESS1 STRESS2
 STRESS3 EXAMPLE NO.   7.   27  STIMULI.   3X3X3  DESIGN.   RANDOM DATA.
(76655659).  1 RANK SUBJECT.  STIMULI ARE IN THE NATURAL ORDER.  (3F7.2)
   2.00   1.00   5.00
   8.00   3.00   6.00
  13.00  11.00  12.00
   9.00   4.00  15.00
  21.00  10.00  18.00
  22.00  16.00  19.00
  14.00   7.00  20.00
  24.00  17.00  25.00
  27.00  23.00  26.00
```

The following example is an illustration of one of the random data sets used in the Nygren (1983) study. The analysis is set for SWAT to test axioms and scale the data in a 3x3x3 design. Simple independence holds for Factors A, B, and C. The data are for one subject with one replication of each judgment. Hence, NREP = 1 and FLAG = NO.

```
YES YES   3   3   3   3   0   0   1   1  NO  -2    0.00 YES   0   3
YES YES YES YES  NO   0 YES YES YES YES  NC  NC  NO
 60       NO YES  NO YES  NO  NO76655659
0.00001 0.00000
  TIME1   TIME2   TIME3 EFFORT1 EFFORT2 EFFORT3 STRESS1 STRESS2
 STRESS3 EXAMPLE NO.   8.   27  STIMULI.   3X3X3  DESIGN.   RANDOM DATA.
(76655659).  1 RANK SUBJECT.  STIMULI ARE IN THE NATURAL ORDER.  (3F7.2)
   1.00    2.00    5.00
   3.00    6.00    8.00
  11.00   12.00   13.00
   4.00    9.00   15.00
  10.00   18.00   21.00
  16.00   19.00   22.00
   7.00   14.00   20.00
  17.00   24.00   25.00
  23.00   26.00   27.00
```

E N D   O F   S W A T   M A N U A L

APPENDIX 2

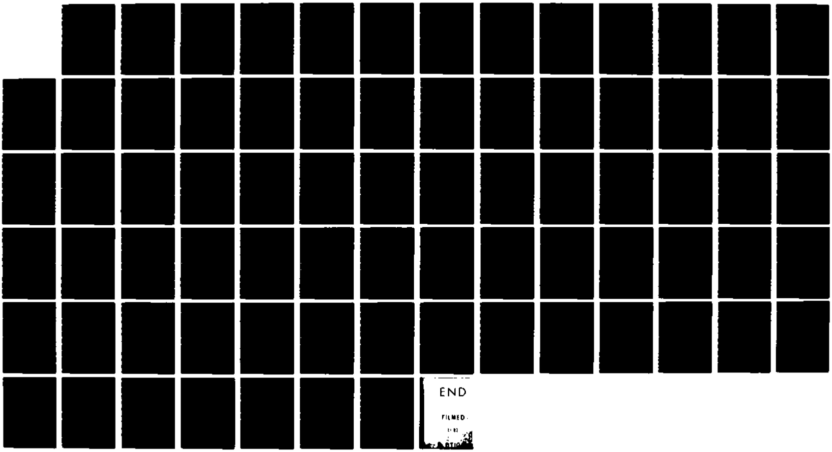
```
  SSSSS   W       W     AAA     TTTTTTT
 S     S  W       W    A   A       T
 S        W       W   A     A      T
  S       W       W   A     A      T
    S     W   W   W   AAAAAAA      T
      S   W  W W  W   A     A      T
       S  W W   W W   A     A      T
 S     S  WW     WW   A     A      T
  SSSSS   W       W   A     A      T
```

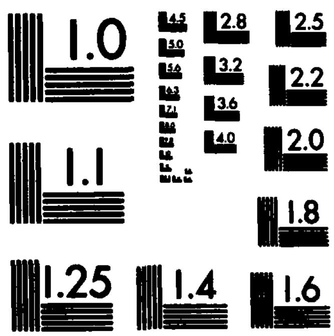
THOMAS E. NYGREN
DEPARTMENT OF PSYCHOLOGY
OHIO STATE UNIVERSITY
404C W. 17TH AVENUE
COLUMBUS, OHIO 43210

SAMPLE PRINTOUT FROM SWAT PROGRAM, VERSION 2.0.

AD-A133 946 INVESTIGATION OF AN ERROR THEORY FOR CONJOINT MEASUREMENT METHODOLOGY(U) OHIO STATE UNIV RESEARCH FOUNDATION COLUMBUS T E NYGREN MAY 83 AFOSR-TR-83-0860 2/2

UNCLASSIFIED AFORR-82-0175 F/G 12/1 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

S U A T 1 :

OSU VERSION 2.0
APRIL, 1983
THOMAS E. NYGREN
DEPARTMENT OF PSYCHOLOGY
OHIO STATE UNIVERSITY
404C W. 17TH AVENUE
COLUMBUS, OHIO

TITLE: EXAMPLE NO. 1.
TITLE: 27 STIMULI. 3X3X3 DESIGN. RANDOM DATA. (76655659).
TITLE: 1 RANK SUBJECT. STIMULI ARE IN THE NATURAL ORDER.

FORMAT FOR READING IN DATA =
(3F7.2)

INITIAL PARAMETERS FOR ANALYSIS:

IAX	- ARE TESTS OF AXIOMS TO BE MADE?	YES
ICON	- IS A CONJOINT SCALING TO BE DONE?	YES
NF	- NUMBER OF FACTORS IN THE DESIGN	3
NBLKS	- NUMBER OF BLOCKS IN THE DESIGN	1
NREP	- NUMBER OF DATA MATRICES TO BE SCALED	1
FLAG	- IS THERE MORE THAN ONE OBSERVATION PER CELL?	NO
INTYP	- METHOD FOR READING IN DATA MATRICES IS:	-2
EMPTY	- MISSING DATA CUTOFF VALUE IS:	0.0
OVRD	- ARE SUBJECTS DATA TO BE AVERAGED REGARDLESS?	YES
JUNIT	- UNIT NUMBER FOR INPUT OF DATA	5
NCARD	- NUMBER OF TITLE/DESCRIPTION CARDS USED	3
PRINT	- MAX NUMBER OF VIOLATIONS TO BE PRINTED	0
SUPRS	- SUPPRESS PRINTING OF CELL VIOLATIONS?	YES

NUMBER OF DIMENSIONS:	DIM (1)	DIM (2)	DIM (3)	DIM (4)	DIM (5)
	3	3	3	0	0

PARAMETERS FOR AXIOM TESTING PROCEDURE:

AXIOMS TO BE TESTED:	AXTEST1	AXTEST2	AXTEST3	AXTEST4	AXTEST5
	(INDEP)	(DBLCAN)	(JINDEP)	(DSTCAN)	(DDCAN)

		YES	YES	YES	YES	NO
DISTLV(1)	DISTLV(2)	DISTLV(3)	DDSTLV(1)	DDSTLV(2)	DDSTLV(3)	
YES	YES	YES	NO	NO	NO	

AVERAGED DATA FROM AVERAGING PROCEDURE: BLOCK 1.

BLOCK	STIMULUS	AVERAGE VALUE
1	1	21.00
1	2	13.00
1	3	24.00
1	4	22.00
1	5	27.00
1	6	8.00
1	7	14.00
1	8	2.00
1	9	9.00
1	10	11.00
1	11	16.00
1	12	23.00
1	13	3.00
1	14	7.00
1	15	4.00
1	16	10.00
1	17	1.00
1	18	17.00
1	19	15.00
1	20	5.00
1	21	26.00
1	22	12.00
1	23	20.00
1	24	19.00
1	25	25.00
1	26	6.00
1	27	18.00

DATA MATRIX BEING CHECKED FOR AXIOM VIOLATIONS.
BLOCK 1. REPLICATION 1 OF 1.

MATRIX BLOCK NO. = 1 C = 1

A =	1	2	3
B = 1	21.00	13.00	24.00
B = 2	22.00	27.00	8.00
B = 3	14.00	2.00	9.00

C = 2

A =	1	2	3
B = 1	11.00	16.00	23.00
B = 2	3.00	7.00	4.00
B = 3	10.00	1.00	17.00

C = 3

A =	1	2	3
B = 1	15.00	5.00	26.00
B = 2	12.00	20.00	19.00
B = 3	25.00	6.00	18.00

ETC.

TEST SUMMARY STATISTICS: INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR INDEPENDENCE:

A INDEPENDENT OF B AND C

BLOCK 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: INDEPENDENCE.

A INDEPENDENT OF B AND C

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	52.0	0.481**********		
FAILURES:	56.0	0.519******************		

INDEPENDENCE: FACTOR C IS THE OUTSIDE FACTOR.

	1	2	3
B OF A	0.333	0.778	0.0
A OF B	0.111	0.444	0.111

ETC.

TEST SUMMARY STATISTICS: INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR INDEPENDENCE:

B INDEPENDENT OF C AND A

BLOCK 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: INDEPENDENCE.

B INDEPENDENT OF C AND A

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	56.0	0.519**********		
FAILURES:	52.0	0.481******************		

INDEPENDENCE: FACTOR A IS THE OUTSIDE FACTOR.

	1	2	3
C OF B	0.778	0.111	0.778
B OF C	0.111	0.444	0.778

ETC.

TEST SUMMARY STATISTICS: INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR INDEPENDENCE:

C INDEPENDENT OF A AND B

BLOCK 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: INDEPENDENCE.

C INDEPENDENT OF A AND B

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	66.0	0.611**********		
FAILURES:	42.0	0.389******************		

INDEPENDENCE: FACTOR B IS THE OUTSIDE FACTOR.

	1	2	3
A OF C	0.778	0.778	0.778
C OF A	0.111	0.778	0.778

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DATA MATRIX BEING CHECKED FOR DOUBLE CANCELLATION: BLOCK 1.

DOUBLE CANCELLATION IN A X B .

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.
TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN A X B

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	3.0			
TOTAL TESTS:	1.0			
SUCCESSES:	0.0	0.0	*********	
FAILURES:	1.0	1.000******************		

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN B X C

NO TESTS ARE POSSIBLE IN THE DATA.

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN C X A

NO TESTS ARE POSSIBLE IN THE DATA.

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

A X B INDEPENDENT OF C .

BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

A X B INDEPENDENT OF C

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	68.0	0.630*********		
FAILURES:	40.0	0.370*****************		

JOINT-INDEPENDENCE: FACTOR C IS THE OUTSIDE FACTOR.

```
  A ,    B   OF    C        W =    0.578
  C   OF    A ,    B        W =    0.346
TEST SUMMARY STATISTICS:  JOINT INDEPENDENCE.
```

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

B X C INDEPENDENT OF A .

BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

B X C INDEPENDENT OF A

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

```
                                               NUMBER  PERCENT  PERCENT  SIGNIF
                                                       OBSERVED EXPECTED

MAXIMUM TESTS POSSIBLE:                         108.0
TOTAL TESTS:                                    108.0
  SUCCESSES:                                     60.0    0.556*********
  FAILURES:                                      48.0    0.444******************


JOINT-INDEPENDENCE:  FACTOR    A  IS THE OUTSIDE FACTOR.

  B ,    C   OF    A        U =    0.437
  A   OF    B ,    C        U =    0.086
TEST SUMMARY STATISTICS:  JOINT INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

 C  X   A  INDEPENDENT OF   B .

BLOCK:   1.

TEST VIOLATIONS:  FIRST   0 FAILURES.

       ETC.

TEST SUMMARY STATISTICS:  JOINT INDEPENDENCE.
```

C X A INDEPENDENT OF B

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	56.0	0.519*********		
FAILURES:	52.0	0.481*****************		

JOINT-INDEPENDENCE: FACTOR B IS THE OUTSIDE FACTOR.

C , A OF B W = 0.374
B OF C , A W = 0.160
TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR A IS THE OUTSIDE FACTOR.

DATA MATRIX BEING CHECKED FOR DISTRIB CANCELLATION: BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR A IS THE OUTSIDE FACTOR.

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	243.0			
TOTAL TESTS:	238.0			
SUCCESSES:	208.0	0.874**********		
FAILURES:	30.0	0.126******************		

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR B IS THE OUTSIDE FACTOR.

DATA MATRIX BEING CHECKED FOR DISTRIB CANCELLATION: BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR B IS THE OUTSIDE FACTOR.

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	243.0			
TOTAL TESTS:	237.0			
SUCCESSES:	215.0	0.907*********		
FAILURES:	22.0	0.093****************		

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR C IS THE OUTSIDE FACTOR.

DATA MATRIX BEING CHECKED FOR DISTRIB CANCELLATION: BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR C IS THE OUTSIDE FACTOR.

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	243.0			
TOTAL TESTS:	242.0			
SUCCESSES:	196.0	0.810*********		
FAILURES:	46.0	0.190*****************		

S W A T 1:

OSU VERSION 2.0
APRIL, 1983
THOMAS E. NYGREN
DEPARTMENT OF PSYCHOLOGY
OHIO STATE UNIVERSITY
404C W. 17TH AVENUE
COLUMBUS, OHIO

N O N M E T R I C

S C A L I N G

DATA MATRIX: BLOCK 1.

```
 MATRIX BLOCK NO. =    1            C = 1
A =                1      2      3
    B = 1      21.00  13.00  24.00
    B = 2      22.00  27.00   8.00
    B = 3      14.00   2.00   9.00


                                    C = 2
A =                1      2      3
    B = 1      11.00  16.00  23.00
    B = 2       3.00   7.00   4.00
    B = 3      10.00   1.00  17.00


                                    C = 3
A =                1      2      3
    B = 1      15.00   5.00  26.00
    B = 2      12.00  20.00  19.00
    B = 3      25.00   6.00  18.00
PARAMETER VALUES FOR DOING CONJOINT SCALING:
```

NF	- NUMBER OF FACTORS IN THE DESIGN	3
N	- TOTAL NUMBER OF LEVELS OF ALL FACTORS	9
NBLKS	- NUMBER OF BLOCKS IN THE DESIGN	1
ITRLIM	- MAXIMUM NUMBER OF ITERATIONS ALLOWED	60
ITIES	- ARE TIES IN DATA TO BE LEFT AS TIES?	NO
LABEL	- ARE LABELS PROVIDED BY THE USER?	YES
NPUN	- IS FINAL SOLUTION TO BE PUNCHED ON CARDS?	NO
LASTIT	- IS SOLUTION FROM LAST ITERATION TO BE USED?	YES
NREVR	- IS INPUT DATA TO BE REVERSED?	NO
IPLOT	- IS A PLOT OF THE FIT TO BE MADE?	NO
IRAN	- RANDOM NUMBER FOR STARTING THE ANALYSIS	76655659
CRITR	- MINIMUM IMPROVEMENT CRITERION	0.00001
START	- CONSTANT TO BE ADDED TO SCALE VALUES	0.0

RANDOM STARTING CONFIGURATION:

0.452	0.392	0.280	0.158	0.424
0.123	0.919	0.408	0.177	

DATA MATRIX: SUBJECT/REPLICATION NO. 1

BLOCK	STIM	LEVELS OF FACTORS								
1	1	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	21.0
1	2	1.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	11.0
1	3	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	15.0
1	4	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	22.0
1	5	1.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	3.0
1	6	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	12.0
1	7	1.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	14.0
1	8	1.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	10.0
1	9	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	25.0
1	10	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	13.0
1	11	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	16.0
1	12	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	5.0
1	13	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	27.0
1	14	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	7.0
1	15	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	20.0
1	16	0.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	2.0
1	17	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0
1	18	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	6.0

1	19	0.0	0.0	1.0	1.0	0.0	0.0	1.0	0.0	0.0	24.0
1	20	0.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	23.0
1	21	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	26.0
1	22	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	8.0
1	23	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	4.0
1	24	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	19.0
1	25	0.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	0.0	9.0
1	26	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	17.0
1	27	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	18.0

HISTORY OF ITERATIVE COMPUTATIONS

ITERATION	THETA	TAU
1	0.75819	0.03704
2	0.25042	0.32764
3	0.23950	0.34473
4	0.23879	0.38462
5	0.23472	0.35613
6	0.23543	0.36752
7	0.23287	0.35613
8	0.23364	0.37892
9	0.23189	0.36182
10	0.23257	0.37892
11	0.23133	0.36182
12	0.23190	0.37892
13	0.23100	0.36182
14	0.23146	0.37892
15	0.23081	0.36182
16	0.23118	0.37892
17	0.23069	0.36182
18	0.23098	0.37892
19	0.23062	0.36182
20	0.23085	0.37892
21	0.23058	0.36182
22	0.23076	0.37892
23	0.23056	0.36182
24	0.23070	0.37892
25	0.23055	0.36182
26	0.23066	0.37892
27	0.23054	0.36182
28	0.23063	0.37892
29	0.23054	0.36182
30	0.23060	0.37892
31	0.23054	0.36182
32	0.23059	0.37892
33	0.23054	0.36182
34	0.23058	0.37892

35	0.23054	0.36182
36	0.23057	0.37892
37	0.23054	0.36182
38	0.23056	0.37892
39	0.23054	0.36182
40	0.23056	0.37892
41	0.23054	0.36182
42	0.23056	0.37892
43	0.23054	0.36182
44	0.23055	0.37892
45	0.23055	0.36182

SCALE VALUES BELOW ARE PRINTED FROM ITERATION NO. 45.

	VARIABLE	ADDITIVE MODEL	ADDITIVE RESCALED	MULTIP MODEL
1	TIME1	-0.19906	27.02457	0.81950
2	TIME2	0.43429	90.35976	1.54387
3	TIME3	-0.22792	24.13876	0.79619
4	EFFORT1	-0.46930	0.0	0.62544
5	EFFORT2	0.09193	56.12321	1.09629
6	EFFORT3	0.38197	85.12750	1.46517
7	STRESS1	-0.17967	28.96304	0.83554
8	STRESS2	0.60735	107.66515	1.83556
9	STRESS3	-0.41786	5.14383	0.65845

ADDITIVE SCALE VALUES FOR 27 STIMULI.

STIM:	LEVELS			STANDARD	RESCALED
1	1	1	1	-0.84803	26.70494
2	1	1	2	-0.06101	105.40704
3	1	1	3	-1.08622	2.88582
4	1	2	1	-0.28680	82.82817
5	1	2	2	0.50022	161.53020
6	1	2	3	-0.52499	59.00894
7	1	3	1	0.00324	111.83243
8	1	3	2	0.79026	190.53448
9	1	3	3	-0.23495	88.01323
10	2	1	1	-0.21468	90.04013
11	2	1	2	0.57234	168.74217
12	2	1	3	-0.45287	66.22090
13	2	2	1	0.34655	146.16327
14	2	2	2	1.13357	224.86543
15	2	2	3	0.10836	122.34410

16	2	3	1	0.63659	175.16756
17	2	3	2	1.42362	253.86972
18	2	3	3	0.39840	151.34839
19	3	1	1	-0.87689	23.81915
20	3	1	2	-0.08987	102.52122
21	3	1	3	-1.11508	0.0
22	3	2	1	-0.31566	79.94237
23	3	2	2	0.47136	158.64449
24	3	2	3	-0.55385	56.12315
25	3	3	1	-0.02562	108.94661
26	3	3	2	0.76141	187.64877
27	3	3	3	-0.26381	85.12744

DEPENDENT & PREDICTIONS SORTED BY DEPENDENT. BLOCK NO. 1.

27.000	0.347
26.000	-1.115
25.000	-0.235
24.000	-0.877
23.000	-0.090
22.000	-0.287
21.000	-0.848
20.000	0.108
19.000	-0.554
18.000	-0.264
17.000	0.761
16.000	0.572
15.000	-1.086
14.000	0.003
13.000	-0.215
12.000	-0.525
11.000	-0.061
10.000	0.790
9.000	-0.026
8.000	-0.316
7.000	1.134
6.000	0.398
5.000	-0.453
4.000	0.471
3.000	0.500
2.000	0.637
1.000	1.424

PREDICTIVE CAPABILITY = 31.054 PERCENT
OR = 68.946 IF DATA ARE IN REVERSE ORDER.

END OF NONMETRIC SCALING ANALYSIS.

END SWAT.

S W A T 1 :

OSU VERSION 2.0
APRIL, 1983
THOMAS E. NYGREN
DEPARTMENT OF PSYCHOLOGY
OHIO STATE UNIVERSITY
404C W. 17TH AVENUE
COLUMBUS, OHIO

TITLE: EXAMPLE NO. 1.
TITLE: 27 STIMULI. 3X3X3 DESIGN. RANDOM DATA. (76655659).
TITLE: 1 RANK SUBJECT. STIMULI ARE IN THE NATURAL ORDER.

FORMAT FOR READING IN DATA =
(3F7.2)

INITIAL PARAMETERS FOR ANALYSIS:

IAX	- ARE TESTS OF AXIOMS TO BE MADE?	YES
ICON	- IS A CONJOINT SCALING TO BE DONE?	YES
NF	- NUMBER OF FACTORS IN THE DESIGN	3
NBLKS	- NUMBER OF BLOCKS IN THE DESIGN	1
NREP	- NUMBER OF DATA MATRICES TO BE SCALED	1
FLAG	- IS THERE MORE THAN ONE OBSERVATION PER CELL?	NO
INTYP	- METHOD FOR READING IN DATA MATRICES IS:	-2
EMPTY	- MISSING DATA CUTOFF VALUE IS:	0.0
OVRD	- ARE SUBJECTS DATA TO BE AVERAGED REGARDLESS?	YES
JUNIT	- UNIT NUMBER FOR INPUT OF DATA	5
NCARD	- NUMBER OF TITLE/DESCRIPTION CARDS USED	3
PRINT	- MAX NUMBER OF VIOLATIONS TO BE PRINTED	0
SUPRS	- SUPPRESS PRINTING OF CELL VIOLATIONS?	YES

NUMBER OF DIMENSIONS:	DIM(1)	DIM(2)	DIM(3)	DIM(4)	DIM(5)
	3	3	3	0	0

PARAMETERS FOR AXIOM TESTING PROCEDURE:

AXIOMS TO BE TESTED:	AXTEST1	AXTEST2	AXTEST3	AXTEST4	AXTEST5
	(INDEP)	(DBLCAN)	(JINDEP)	(DSTCAN)	(DDCAN)

YES YES YES YES NO

DISTLV(1)	DISTLV(2)	DISTLV(3)	DDSTLV(1)	DDSTLV(2)	DDSTLV(3)
YES	YES	YES	NO	NO	NO

AVERAGED DATA FROM AVERAGING PROCEDURE: BLOCK 1.

BLOCK	STIMULUS	AVERAGE VALUE
1	1	13.00
1	2	21.00
1	3	24.00
1	4	8.00
1	5	22.00
1	6	27.00
1	7	2.00
1	8	9.00
1	9	14.00
1	10	11.00
1	11	16.00
1	12	23.00
1	13	3.00
1	14	4.00
1	15	7.00
1	16	1.00
1	17	10.00
1	18	17.00
1	19	5.00
1	20	15.00
1	21	26.00
1	22	12.00
1	23	19.00
1	24	20.00
1	25	6.00
1	26	18.00
1	27	25.00

DATA MATRIX BEING CHECKED FOR AXIOM VIOLATIONS.
BLOCK 1. REPLICATION 1 OF 1.

MATRIX BLOCK NO. = 1 C = 1

A =	1	2	3
B = 1	13.00	21.00	24.00
B = 2	8.00	22.00	27.00
B = 3	2.00	9.00	14.00

C = 2

A =	1	2	3
B = 1	11.00	16.00	23.00
B = 2	3.00	4.00	7.00
B = 3	1.00	10.00	17.00

C = 3

A =	1	2	3
B = 1	5.00	15.00	26.00
B = 2	12.00	19.00	20.00
B = 3	6.00	18.00	25.00

TEST SUMMARY STATISTICS: INDEPENDENCE.

A INDEPENDENT OF B AND C

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	108.0	1.000	*********	
FAILURES:	0.0	0.0	*****************	

INDEPENDENCE: FACTOR C IS THE OUTSIDE FACTOR.

1 2 3

B	OF	A	0.778	0.778	0.111
A	OF	B	1.000	1.000	1.000

ETC.

TEST SUMMARY STATISTICS: INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR INDEPENDENCE:

B INDEPENDENT OF C AND A

BLOCK 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: INDEPENDENCE.

B INDEPENDENT OF C AND A

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	56.0	0.519*********		
FAILURES:	52.0	0.481*****************		

INDEPENDENCE: FACTOR A IS THE OUTSIDE FACTOR.

	1	2	3
C OF B	0.333	0.111	0.444
B OF C	0.333	0.111	0.333
ETC.			

TEST SUMMARY STATISTICS: INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR INDEPENDENCE:

C INDEPENDENT OF A AND B

BLOCK 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: INDEPENDENCE.

C INDEPENDENT OF A AND B

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	60.0	0.556*********		

FAILURES: 48.0 0.444*****************

INDEPENDENCE: FACTOR B IS THE OUTSIDE FACTOR.

		1	2	3
A OF C		1.000	1.000	1.000
C OF A		0.333	0.778	0.778

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN A X B

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	3.0			
TOTAL TESTS:	2.0			
SUCCESSES:	2.0	1.000*********		
FAILURES:	0.0	0.0 ****************		

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN B X C

NO TESTS ARE POSSIBLE IN THE DATA.

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN C X A

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	3.0			
TOTAL TESTS:	1.0			
SUCCESSES:	1.0	1.000*********		
FAILURES:	0.0	0.0	*****************	

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

A X B INDEPENDENT OF C .

BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

A X B INDEPENDENT OF C

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	80.0	0.741*********		
FAILURES:	28.0	0.259*****************		

JOINT-INDEPENDENCE: FACTOR C IS THE OUTSIDE FACTOR.

A , B OF C W = 0.726
C OF A , B W = 0.235
TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

B X C INDEPENDENT OF A .

BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

B X C INDEPENDENT OF A

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	80.0	0.741**********		
FAILURES:	28.0	0.259******************		

JOINT-INDEPENDENCE: FACTOR A IS THE OUTSIDE FACTOR.

B , C OF A W = 0.778
A OF B , C W = 1.000
TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

C X A INDEPENDENT OF B .

BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

C X A INDEPENDENT OF B

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	78.0	0.722*********		
FAILURES:	30.0	0.278******************		

JOINT-INDEPENDENCE: FACTOR B IS THE OUTSIDE FACTOR.

```
  C ,    A   OF    B        W =    0.719
  B   OF    C ,    A        W =    0.160
```

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR A IS THE OUTSIDE FACTOR.

DATA MATRIX BEING CHECKED FOR DISTRIB CANCELLATION: BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR A IS THE OUTSIDE FACTOR.

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	243.0			
TOTAL TESTS:	243.0			
SUCCESSES:	235.0	0.967*********		

FAILURES: 8.0 0.033*****************

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR B IS THE OUTSIDE FACTOR.

DATA MATRIX BEING CHECKED FOR DISTRIB CANCELLATION: BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR B IS THE OUTSIDE FACTOR.

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	243.0			
TOTAL TESTS:	235.0			
SUCCESSES:	227.0	0.966*********		
FAILURES:	8.0	0.034*****************		

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR C IS THE OUTSIDE FACTOR.

DATA MATRIX BEING CHECKED FOR DISTRIB CANCELLATION: BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR C IS THE OUTSIDE FACTOR.

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	243.0			
TOTAL TESTS:	224.0			
SUCCESSES:	218.0	0.973*********		
FAILURES:	6.0	0.027****************		

S W A T 1:

OSU VERSION 2.0
APRIL, 1983
THOMAS E. NYGREN
DEPARTMENT OF PSYCHOLOGY
OHIO STATE UNIVERSITY
404C W. 17TH AVENUE
COLUMBUS, OHIO

N O N M E T R I C

S C A L I N G

DATA MATRIX: BLOCK 1.

MATRIX BLOCK NO. = 1 C = 1

A =	1	2	3
B = 1	13.00	21.00	24.00
B = 2	8.00	22.00	27.00
B = 3	2.00	9.00	14.00

C = 2

A =	1	2	3
B = 1	11.00	16.00	23.00
B = 2	3.00	4.00	7.00
B = 3	1.00	10.00	17.00

C = 3

A =	1	2	3
B = 1	5.00	15.00	26.00
B = 2	12.00	19.00	20.00
B = 3	6.00	18.00	25.00

PARAMETER VALUES FOR DOING CONJOINT SCALING:

NF	- NUMBER OF FACTORS IN THE DESIGN	3
N	- TOTAL NUMBER OF LEVELS OF ALL FACTORS	9
NBLKS	- NUMBER OF BLOCKS IN THE DESIGN	1
ITMLIM	- MAXIMUM NUMBER OF ITERATIONS ALLOWED	60
ITIES	- ARE TIES IN DATA TO BE LEFT AS TIES?	NO
LABEL	- ARE LABELS PROVIDED BY THE USER?	YES
NPUN	- IS FINAL SOLUTION TO BE PUNCHED ON CARDS?	NO
LASTIT	- IS SOLUTION FROM LAST ITERATION TO BE USED?	YES
NREVR	- IS INPUT DATA TO BE REVERSED?	NO
IPLOT	- IS A PLOT OF THE FIT TO BE MADE?	NO
IRAN	- RANDOM NUMBER FOR STARTING THE ANALYSIS	76655659
CRITR	- MINIMUM IMPROVEMENT CRITERION	0.00001
START	- CONSTANT TO BE ADDED TO SCALE VALUES	0.0

RANDOM STARTING CONFIGURATION:

0.452	0.392	0.280	0.158	0.424
0.123	0.919	0.408	0.177	

DATA MATRIX: SUBJECT/REPLICATION NO. 1

BLOCK	STIM	LEVELS OF FACTORS									
1	1	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	13.0
1	2	1.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	11.0
1	3	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	5.0
1	4	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	8.0
1	5	1.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	3.0
1	6	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	12.0
1	7	1.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	2.0
1	8	1.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0
1	9	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	6.0
1	10	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	21.0
1	11	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	16.0
1	12	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	15.0
1	13	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	22.0
1	14	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	4.0
1	15	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	19.0
1	16	0.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	9.0
1	17	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	10.0
1	18	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	18.0

1	19	0.0	0.0	1.0	1.0	0.0	0.0	1.0	0.0	0.0	24.0
1	20	0.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	23.0
1	21	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	26.0
1	22	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	27.0
1	23	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	7.0
1	24	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	20.0
1	25	0.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	0.0	14.0
1	26	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	17.0
1	27	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	25.0

HISTORY OF ITERATIVE COMPUTATIONS

ITERATION	THETA	TAU
1	0.71267	0.12251
2	0.17376	0.52137
3	0.14245	0.63533
4	0.15914	0.63533
5	0.14812	0.64672
6	0.16152	0.62963
7	0.15099	0.62393
8	0.15612	0.64103
9	0.15085	0.62393
10	0.15320	0.64103
11	0.15047	0.62393
12	0.15152	0.64103
13	0.15006	0.62393
14	0.15048	0.63533
15	0.14969	0.64103
16	0.14981	0.63533
17	0.14937	0.64103
18	0.14936	0.63533
19	0.14912	0.64103
20	0.14905	0.62963
21	0.14892	0.64103
22	0.14884	0.62963
23	0.14877	0.64103
24	0.14868	0.62963
25	0.14864	0.64103
26	0.14857	0.62963
27	0.14855	0.64103
28	0.14849	0.62963
29	0.14848	0.64103

SCALE VALUES BELOW ARE PRINTED FROM ITERATION NO. 29.

	VARIABLE	ADDITIVE MODEL	ADDITIVE RESCALED	MULTIP MODEL
1	TIME1	0.57923	98.11780	1.78467
2	TIME2	-0.07884	32.31015	0.92419
3	TIME3	-0.40194	0.0	0.66902
4	EFFORT1	-0.33958	6.23605	0.71207
5	EFFORT2	0.08922	49.11652	1.09332
6	EFFORT3	0.31210	71.40445	1.36629
7	STRESS1	-0.14392	25.80217	0.86596
8	STRESS2	0.56547	96.74135	1.76027
9	STRESS3	-0.28989	11.20537	0.74835

ADDITIVE SCALE VALUES FOR 27 STIMULI.

STIM:	LEVELS			STANDARD	RESCALED
1	1	1	1	0.09573	112.71448
2	1	1	2	0.80512	183.65364
3	1	1	3	-0.05024	98.11772
4	1	2	1	0.52453	155.59491
5	1	2	2	1.23393	226.53416
6	1	2	3	0.37857	140.99817
7	1	3	1	0.74741	177.88286
8	1	3	2	1.45681	248.82211
9	1	3	3	0.60145	163.28610
10	2	1	1	-0.56235	46.90688
11	2	1	2	0.14704	117.84601
12	2	1	3	-0.70832	32.31007
13	2	2	1	-0.13354	89.78735
14	2	2	2	0.57585	160.72644
15	2	2	3	-0.27951	75.19055
16	2	3	1	0.08934	112.07523
17	2	3	2	0.79873	183.01439
18	2	3	3	-0.05663	97.47849
19	3	1	1	-0.88545	14.59673
20	3	1	2	-0.17606	85.53589
21	3	1	3	-1.03142	0.0
22	3	2	1	-0.45664	57.47720
23	3	2	2	0.25275	128.41634
24	3	2	3	-0.60261	42.88040
25	3	3	1	-0.23376	79.76514
26	3	3	2	0.47563	150.70428
27	3	3	3	-0.37973	65.16833

DEPENDENT & PREDICTIONS SORTED BY DEPENDENT. BLOCK NO. 1.

27.000 -0.457

26.000	-1.031
25.000	-0.380
24.000	-0.885
23.000	-0.176
22.000	-0.134
21.000	-0.562
20.000	-0.603
19.000	-0.280
18.000	-0.057
17.000	0.476
16.000	0.147
15.000	-0.708
14.000	-0.234
13.000	0.096
12.000	0.379
11.000	0.805
10.000	0.799
9.000	0.089
8.000	0.525
7.000	0.253
6.000	0.601
5.000	-0.050
4.000	0.576
3.000	1.234
2.000	0.747
1.000	1.457

PREDICTIVE CAPABILITY = 18.519 PERCENT
OR = 81.481 IF DATA ARE IN REVERSE ORDER.

END OF NONMETRIC SCALING ANALYSIS.

END SWAT.

S W A T 1 :

OSU VERSION 2.0
APRIL, 1983
THOMAS E. NYGREN
DEPARTMENT OF PSYCHOLOGY
OHIO STATE UNIVERSITY
404C W. 17TH AVENUE
COLUMBUS, OHIO

TITLE: EXAMPLE NO. 1.
TITLE: 27 STIMULI. 3X3X3 DESIGN. RANDOM DATA. (76655659).
TITLE: 1 RANK SUBJECT. STIMULI ARE IN THE NATURAL ORDER.

FORMAT FOR READING IN DATA =
(3F7.2)

INITIAL PARAMETERS FOR ANALYSIS:

IAX	- ARE TESTS OF AXIOMS TO BE MADE?	YES
ICON	- IS A CONJOINT SCALING TO BE DONE?	YES
NF	- NUMBER OF FACTORS IN THE DESIGN	3
NBLKS	- NUMBER OF BLOCKS IN THE DESIGN	1
NREP	- NUMBER OF DATA MATRICES TO BE SCALED	1
FLAG	- IS THERE MORE THAN ONE OBSERVATION PER CELL?	NO
INTYP	- METHOD FOR READING IN DATA MATRICES IS:	-2
EMPTY	- MISSING DATA CUTOFF VALUE IS:	0.0
OVRD	- ARE SUBJECTS DATA TO BE AVERAGED REGARDLESS?	YES
JUNIT	- UNIT NUMBER FOR INPUT OF DATA	5
NCARD	- NUMBER OF TITLE/DESCRIPTION CARDS USED	3
PRINT	- MAX NUMBER OF VIOLATIONS TO BE PRINTED	0
SUPRS	- SUPPRESS PRINTING OF CELL VIOLATIONS?	YES

NUMBER OF DIMENSIONS:	DIM(1)	DIM(2)	DIM(3)	DIM(4)	DIM(5)
	3	3	3	0	0

PARAMETERS FOR AXIOM TESTING PROCEDURE:

AXIOMS TO BE TESTED:	AXTEST1	AXTEST2	AXTEST3	AXTEST4	AXTEST5
	(INDEP)	(DBLCAN)	(JINDEP)	(DSTCAN)	(DDCAN)

		YES	YES	YES	YES	NO
DISTLV(1)	DISTLV(2)	DISTLV(3)	DDSTLV(1)	DDSTLV(2)	DDSTLV(3)	
YES	YES	YES	NO	NO	NO	

AVERAGED DATA FROM AVERAGING PROCEDURE: BLOCK 1.

BLOCK	STIMULUS	AVERAGE VALUE
1	1	2.00
1	2	9.00
1	3	14.00
1	4	8.00
1	5	21.00
1	6	24.00
1	7	13.00
1	8	22.00
1	9	27.00
1	10	1.00
1	11	4.00
1	12	7.00
1	13	3.00
1	14	10.00
1	15	17.00
1	16	11.00
1	17	16.00
1	18	23.00
1	19	5.00
1	20	15.00
1	21	20.00
1	22	6.00
1	23	18.00
1	24	25.00
1	25	12.00
1	26	19.00
1	27	26.00

DATA MATRIX BEING CHECKED FOR AXIOM VIOLATIONS.
BLOCK 1. REPLICATION 1 OF 1.

MATRIX BLOCK NO. = 1 C = 1

A =	1	2	3
B = 1	2.00	9.00	14.00
B = 2	8.00	21.00	24.00
B = 3	13.00	22.00	27.00

C = 2

A =	1	2	3
B = 1	1.00	4.00	7.00
B = 2	3.00	10.00	17.00
B = 3	11.00	16.00	23.00

C = 3

A =	1	2	3
B = 1	5.00	15.00	20.00
B = 2	6.00	18.00	25.00
B = 3	12.00	19.00	26.00

TEST SUMMARY STATISTICS: INDEPENDENCE.

A INDEPENDENT OF B AND C

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	108.0	1.000	*********	
FAILURES:	0.0	0.0	****************	

INDEPENDENCE: FACTOR C IS THE OUTSIDE FACTOR.

1 2 3

```
  B   OF    A          1.000     1.000     1.000
  A   OF    B          1.000     1.000     1.000
TEST SUMMARY STATISTICS:  INDEPENDENCE.



  B  INDEPENDENT OF   C  AND   A


THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

                                  NUMBER  PERCENT  PERCENT  SIGNIF
                                          OBSERVED EXPECTED

MAXIMUM TESTS POSSIBLE:            108.0
TOTAL TESTS:                       108.0
  SUCCESSES:                       108.0    1.000*********
  FAILURES:                          0.0    0.0  ****************



INDEPENDENCE:  FACTOR    A  IS THE OUTSIDE FACTOR.

                         1         2         3
  C   OF    B          0.778     0.778     0.778
  B   OF    C          1.000     1.000     1.000
        ETC.


TEST SUMMARY STATISTICS:  INDEPENDENCE.


DATA MATRIX BEING CHECKED FOR INDEPENDENCE:


 C  INDEPENDENT OF   A  AND   B
```

BLOCK 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

TEST SUMMARY STATISTICS: INDEPENDENCE.

C INDEPENDENT OF A AND B

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	88.0	0.815*********		
FAILURES:	20.0	0.185****************		

INDEPENDENCE: FACTOR B IS THE OUTSIDE FACTOR.

	1	2	3
A OF C	1.000	1.000	1.000
C OF A	1.000	0.778	1.000

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DATA MATRIX BEING CHECKED FOR DOUBLE CANCELLATION: BLOCK 1.

DOUBLE CANCELLATION IN A X B .

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN A X B

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	3.0			
TOTAL TESTS:	3.0			
SUCCESSES:	2.0	0.667*********		
FAILURES:	1.0	0.333*****************		

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN B X C

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	3.0			
TOTAL TESTS:	1.0			
SUCCESSES:	1.0	1.000*********		
FAILURES:	0.0	0.0	****************	

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN C X A

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	3.0			
TOTAL TESTS:	1.0			
SUCCESSES:	1.0	1.000*********		
FAILURES:	0.0	0.0	****************	

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

A X B INDEPENDENT OF C .

BLOCK: 1.

```
TEST VIOLATIONS:  FIRST   0 FAILURES.

         ETC.

TEST SUMMARY STATISTICS:  JOINT INDEPENDENCE.



  A  X   B  INDEPENDENT OF   C

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

                                      NUMBER  PERCENT  PERCENT  SIGNIF
                                             OBSERVED EXPECTED

MAXIMUM TESTS POSSIBLE:                108.0
TOTAL TESTS:                           108.0
  SUCCESSES:                            98.0    0.907*********
  FAILURES:                             10.0    0.093*****************



JOINT-INDEPENDENCE:  FACTOR    C  IS THE OUTSIDE FACTOR.

  A ,    B   OF    C        W =    0.937
  C   OF    A ,    B        W =    0.753
TEST SUMMARY STATISTICS:  JOINT INDEPENDENCE.
```

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

B X C INDEPENDENT OF A .

BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

B X C INDEPENDENT OF A

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	100.0	0.926*********		
FAILURES:	8.0	0.074*****************		

JOINT-INDEPENDENCE: FACTOR A IS THE OUTSIDE FACTOR.

```
  B ,    C   OF    A        W =    0.956
  A   OF    B ,    C        W =    1.000
```

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

C X A INDEPENDENT OF B .

BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

C X A INDEPENDENT OF B

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	94.0	0.870*********		
FAILURES:	14.0	0.130****************		

JOINT-INDEPENDENCE: FACTOR B IS THE OUTSIDE FACTOR.

```
  C ,   A   OF   B       W =   0.919
  B   OF   C ,   A       W =   1.000
TEST SUMMARY STATISTICS:  DISTRIB CANCELLATION.
```

FACTOR A IS THE OUTSIDE FACTOR.

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

```
                                NUMBER  PERCENT  PERCENT  SIGNIF
                                        OBSERVED EXPECTED

MAXIMUM TESTS POSSIBLE:          243.0
TOTAL TESTS:                     240.0
  SUCCESSES:                     240.0     1.000*********
  FAILURES:                        0.0     0.0  ****************
```

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR B IS THE OUTSIDE FACTOR.

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	243.0			
TOTAL TESTS:	231.0			
SUCCESSES:	231.0	1.000*********		
FAILURES:	0.0	0.0	****************	

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR C IS THE OUTSIDE FACTOR.

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

NUMBER	PERCENT	PERCENT	SIGNIF

	OBSERVED	EXPECTED	
MAXIMUM TESTS POSSIBLE:	243.0		
TOTAL TESTS:	221.0		
SUCCESSES:	221.0	1.000*********	
FAILURES:	0.0	0.0	*****************

```
S   N   A   T   1 :

                                        OSU VERSION 2.0
                                           APRIL, 1983
                                      THOMAS E. NYGREN
                               DEPARTMENT OF PSYCHOLOGY
                                 OHIO STATE UNIVERSITY
                                    404C W. 17TH AVENUE
                                         COLUMBUS, OHIO

N   O   N   M   E   T   R   I   C

S   C   A   L   I   N   G

DATA MATRIX:  BLOCK  1.

 MATRIX BLOCK NO. =    1            C = 1
A =             1       2       3
   B = 1      2.00    9.00   14.00
   B = 2      8.00   21.00   24.00
   B = 3     13.00   22.00   27.00

                                    C = 2
A =             1       2       3
   B = 1      1.00    4.00    7.00
   B = 2      3.00   10.00   17.00
   B = 3     11.00   16.00   23.00

                                    C = 3
A =             1       2       3
   B = 1      5.00   15.00   20.00
   B = 2      6.00   18.00   25.00
   B = 3     12.00   19.00   26.00
PARAMETER VALUES FOR DOING CONJOINT SCALING:
```

NF	- NUMBER OF FACTORS IN THE DESIGN	3
M	- TOTAL NUMBER OF LEVELS OF ALL FACTORS	9
NBLKS	- NUMBER OF BLOCKS IN THE DESIGN	1
ITRLIM	- MAXIMUM NUMBER OF ITERATIONS ALLOWED	60
ITIES	- ARE TIES IN DATA TO BE LEFT AS TIES?	NO
LABEL	- ARE LABELS PROVIDED BY THE USER?	YES
NPUN	- IS FINAL SOLUTION TO BE PUNCHED ON CARDS?	NO
LASTIT	- IS SOLUTION FROM LAST ITERATION TO BE USED?	YES
NREVR	- IS INPUT DATA TO BE REVERSED?	NO
IPLOT	- IS A PLOT OF THE FIT TO BE MADE?	NO
IRAN	- RANDOM NUMBER FOR STARTING THE ANALYSIS	76655659
CRITR	- MINIMUM IMPROVEMENT CRITERION	0.00001
START	- CONSTANT TO BE ADDED TO SCALE VALUES	0.0

RANDOM STARTING CONFIGURATION:

0.452	0.392	0.280	0.158	0.424
0.123	0.919	0.408	0.177	

DATA MATRIX: SUBJECT/REPLICATION NO. 1

BLOCK	STIM	LEVELS OF FACTORS									
1	1	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	2.0
1	2	1.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0
1	3	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	5.0
1	4	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	8.0
1	5	1.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	3.0
1	6	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	6.0
1	7	1.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	13.0
1	8	1.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	11.0
1	9	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	12.0
1	10	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	9.0
1	11	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	4.0
1	12	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	15.0
1	13	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	21.0
1	14	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	10.0
1	15	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	18.0
1	16	0.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	22.0
1	17	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	16.0
1	18	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	19.0

1	19	0.0	0.0	1.0	1.0	0.0	0.0	1.0	0.0	0.0	14.0
1	20	0.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	7.0
1	21	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	20.0
1	22	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	24.0
1	23	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	17.0
1	24	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	25.0
1	25	0.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	0.0	27.0
1	26	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	23.0
1	27	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	26.0

HISTORY OF ITERATIVE COMPUTATIONS

ITERATION	THETA	TAU
1	0.69915	0.13390
2	0.09606	0.66952
3	0.03770	0.85185
4	0.03816	0.76068
5	0.04278	0.83476
6	0.04127	0.76068
7	0.04091	0.81766
8	0.04118	0.79487
9	0.04079	0.81766
10	0.04127	0.81766
11	0.04064	0.81766
12	0.04031	0.81197
13	0.04008	0.82336
14	0.03968	0.80627
15	0.03955	0.82336
16	0.03920	0.81197
17	0.03909	0.82906
18	0.03878	0.81766
19	0.03869	0.82906
20	0.03842	0.81766
21	0.03834	0.82906
22	0.03810	0.81766
23	0.03804	0.82906
24	0.03783	0.81766
25	0.03777	0.82906
26	0.03758	0.81766
27	0.03753	0.82906
28	0.03736	0.81766
29	0.03732	0.82906
30	0.03717	0.81766
31	0.03713	0.82906
32	0.03699	0.81766
33	0.03696	0.82906
34	0.03684	0.81766

35	0.03681	0.82336
36	0.03670	0.81766
37	0.03667	0.82336
38	0.03657	0.81766
39	0.03654	0.82336
40	0.03645	0.83476
41	0.03643	0.82336
42	0.03634	0.83476
43	0.03632	0.82906
44	0.03625	0.83476
45	0.03623	0.82906
46	0.03616	0.81766
47	0.03614	0.82906
48	0.03608	0.83476
49	0.03607	0.82906

SCALE VALUES BELOW ARE PRINTED FROM ITERATION NO. 49.

	VARIABLE	ADDITIVE MODEL	ADDITIVE RESCALED	MULTIP MODEL
1	TIME1	0.53627	91.02934	1.70961
2	TIME2	0.06835	44.23808	1.07074
3	TIME3	-0.33720	3.68282	0.71377
4	EFFORT1	0.53945	91.34785	1.71507
5	EFFORT2	0.00231	37.63358	1.00231
6	EFFORT3	-0.37403	0.0	0.68796
7	STRESS1	0.02237	39.64011	1.02263
8	STRESS2	0.43457	80.85989	1.54430
9	STRESS3	-0.09924	27.47910	0.90553

ADDITIVE SCALE VALUES FOR 27 STIMULI.

STIM:	LEVELS			STANDARD	RESCALED
1	1	1	1	1.09809	190.85530
2	1	1	2	1.51029	232.07501
3	1	1	3	0.97648	178.69434
4	1	2	1	0.56095	137.14104
5	1	2	2	0.97315	178.36084
6	1	2	3	0.43934	124.98006
7	1	3	1	0.18461	99.50754
8	1	3	2	0.59681	140.72733
9	1	3	3	0.06300	87.34653
10	2	1	1	0.63018	144.06404
11	2	1	2	1.04238	185.28384

12	2	1	3	0.50857	131.90308
13	2	2	1	0.09304	90.34985
14	2	2	2	0.50524	131.56956
15	2	2	3	-0.02857	78.18884
16	2	3	1	-0.28330	52.71628
17	2	3	2	0.12890	93.93607
18	2	3	3	-0.40491	40.55527
19	3	1	1	0.22463	103.50885
20	3	1	2	0.63683	144.72865
21	3	1	3	0.10302	91.34785
22	3	2	1	-0.31252	49.79459
23	3	2	2	0.09968	91.01437
24	3	2	3	-0.43413	37.63358
25	3	3	1	-0.68885	12.16102
26	3	3	2	-0.27665	53.38080
27	3	3	3	-0.81046	0.0

DEPENDENT & PREDICTIONS SORTED BY DEPENDENT. BLOCK NO. 1.

27.000	-0.689
26.000	-0.810
25.000	-0.434
24.000	-0.313
23.000	-0.277
22.000	-0.283
21.000	0.093
20.000	0.103
19.000	-0.405
18.000	-0.029
17.000	0.100
16.000	0.129
15.000	0.509
14.000	0.225
13.000	0.185
12.000	0.063
11.000	0.597
10.000	0.505
9.000	0.630
8.000	0.561
7.000	0.637
6.000	0.439
5.000	0.976
4.000	1.042
3.000	0.973
2.000	1.098
1.000	1.510

PREDICTIVE CAPABILITY = 9.117 PERCENT
OR = 90.883 IF DATA ARE IN REVERSE ORDER.

END OF NONMETRIC SCALING ANALYSIS.

END SWAT.

S W A T 1 :

OSU VERSION 2.0
APRIL, 1983
THOMAS E. NYGREN
DEPARTMENT OF PSYCHOLOGY
OHIO STATE UNIVERSITY
404C W. 17TH AVENUE
COLUMBUS, OHIO

TITLE: EXAMPLE NO. 1.
TITLE: 27 STIMULI. 3X3X3 DESIGN. RANDOM DATA. (76655659).
TITLE: 1 RANK SUBJECT. STIMULI ARE IN THE NATURAL ORDER.

FORMAT FOR READING IN DATA =
(3F7.2)

INITIAL PARAMETERS FOR ANALYSIS:

IAX	- ARE TESTS OF AXIOMS TO BE MADE?	YES
ICON	- IS A CONJOINT SCALING TO BE DONE?	YES
NF	- NUMBER OF FACTORS IN THE DESIGN	3
NBLKS	- NUMBER OF BLOCKS IN THE DESIGN	1
NREP	- NUMBER OF DATA MATRICES TO BE SCALED	1
FLAG	- IS THERE MORE THAN ONE OBSERVATION PER CELL?	NO
INTYP	- METHOD FOR READING IN DATA MATRICES IS:	-2
EMPTY	- MISSING DATA CUTOFF VALUE IS:	0.0
OVRD	- ARE SUBJECTS DATA TO BE AVERAGED REGARDLESS?	YES
JUNIT	- UNIT NUMBER FOR INPUT OF DATA	5
NCARD	- NUMBER OF TITLE/DESCRIPTION CARDS USED	3
PRINT	- MAX NUMBER OF VIOLATIONS TO BE PRINTED	0
SUPRS	- SUPPRESS PRINTING OF CELL VIOLATIONS?	YES

NUMBER OF DIMENSIONS:	DIM(1)	DIM(2)	DIM(3)	DIM(4)	DIM(5)
	3	3	3	0	0

PARAMETERS FOR AXIOM TESTING PROCEDURE:

AXIOMS TO BE TESTED:	AXTEST1	AXTEST2	AXTEST3	AXTEST4	AXTEST5
	(INDEP)	(DBLCAN)	(JINDEP)	(DSTCAN)	(DDCAN)

		YES	YES	YES	YES NO
DISTLV(1)	DISTLV(2)	DISTLV(3)	DDSTLV(1)	DDSTLV(2)	DDSTLV(3)
YES	YES	YES	NO	NO	NO

AVERAGED DATA FROM AVERAGING PROCEDURE: BLOCK 1.

BLOCK	STIMULUS	AVERAGE VALUE
1	1	1.00
1	2	4.00
1	3	7.00
1	4	3.00
1	5	10.00
1	6	17.00
1	7	11.00
1	8	16.00
1	9	23.00
1	10	2.00
1	11	9.00
1	12	14.00
1	13	6.00
1	14	18.00
1	15	24.00
1	16	12.00
1	17	19.00
1	18	26.00
1	19	5.00
1	20	15.00
1	21	20.00
1	22	8.00
1	23	21.00
1	24	25.00
1	25	13.00
1	26	22.00
1	27	27.00

DATA MATRIX BEING CHECKED FOR AXIOM VIOLATIONS.
BLOCK 1. REPLICATION 1 OF 1.

MATRIX BLOCK NO. = 1 C = 1

A =	1	2	3
B = 1	1.00	4.00	7.00
B = 2	3.00	10.00	17.00
B = 3	11.00	16.00	23.00

C = 2

A =	1	2	3
B = 1	2.00	9.00	14.00
B = 2	6.00	18.00	24.00
B = 3	12.00	19.00	26.00

C = 3

A =	1	2	3
B = 1	5.00	15.00	20.00
B = 2	8.00	21.00	25.00
B = 3	13.00	22.00	27.00

TEST SUMMARY STATISTICS: INDEPENDENCE.

A INDEPENDENT OF B AND C

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	108.0	1.000*********		
FAILURES:	0.0	0.0	****************	

INDEPENDENCE: FACTOR C IS THE OUTSIDE FACTOR.

1 2 3

B	OF	A	1.000	1.000	1.000
A	OF	B	1.000	1.000	1.000

TEST SUMMARY STATISTICS: INDEPENDENCE.

B INDEPENDENT OF C AND A

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF .
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	108.0	1.000	*********	
FAILURES:	0.0	0.0	*********	********

INDEPENDENCE: FACTOR A IS THE OUTSIDE FACTOR.

			1	2	3
C	OF	B	1.000	1.000	1.000
B	OF	C	1.000	1.000	1.000

TEST SUMMARY STATISTICS: INDEPENDENCE.

C INDEPENDENT OF A AND B

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.

SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	108.0	1.000*********		
FAILURES:	0.0	0.0	****************	

INDEPENDENCE: FACTOR B IS THE OUTSIDE FACTOR.

	1	2	3
A OF C	1.000	1.000	1.000
C OF A	1.000	1.000	1.000

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DATA MATRIX BEING CHECKED FOR DOUBLE CANCELLATION: BLOCK 1.

DOUBLE CANCELLATION IN A X B .

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN A X B

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.

SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	3.0			
TOTAL TESTS:	3.0			
SUCCESSES:	2.0	0.667	*********	
FAILURES:	1.0	0.333	*****************	

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN B X C

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	3.0			
TOTAL TESTS:	2.0			
SUCCESSES:	2.0	1.000	*********	
FAILURES:	0.0	0.0	*****************	

TEST SUMMARY STATISTICS: DOUBLE CANCELLATION.

DOUBLE CANCELLATION IN C X A

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	3.0			
TOTAL TESTS:	2.0			
SUCCESSES:	2.0	1.000*********		
FAILURES:	0.0	0.0	*****************	

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

A X B INDEPENDENT OF C .

BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

A X B INDEPENDENT OF C

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	102.0	0.944**********		
FAILURES:	6.0	0.056*****************		

JOINT-INDEPENDENCE: FACTOR C IS THE OUTSIDE FACTOR.

A , B OF C W = 0.963
C OF A , B W = 1.000
TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

B X C INDEPENDENT OF A .

BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

ETC.

TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

B X C INDEPENDENT OF A

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	108.0			
TOTAL TESTS:	108.0			
SUCCESSES:	102.0	0.944**********		
FAILURES:	6.0	0.056*****************		

JOINT-INDEPENDENCE: FACTOR A IS THE OUTSIDE FACTOR.

B , C OF A W = 0.967
A OF B , C W = 1.000
TEST SUMMARY STATISTICS: JOINT INDEPENDENCE.

DATA MATRIX BEING CHECKED FOR JOINT INDEPENDENCE:

C X A INDEPENDENT OF B .

BLOCK: 1.

TEST VIOLATIONS: FIRST 0 FAILURES.

```
ETC.


TEST SUMMARY STATISTICS:  JOINT INDEPENDENCE.



  C  X   A  INDEPENDENT OF   B


THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

                                   NUMBER  PERCENT  PERCENT  SIGNIF
                                           OBSERVED EXPECTED


MAXIMUM TESTS POSSIBLE:             108.0
TOTAL TESTS:                        108.0
  SUCCESSES:                        100.0    0.926*********
  FAILURES:                           8.0    0.074*****************



JOINT-INDEPENDENCE:  FACTOR   [illegible]  IS THE OUTSIDE FACTOR.


  C ,   A   OF   B       W =    0.959
  B  OF   C ,   A        W =    1.000
TEST SUMMARY STATISTICS:  DISTRIB CANCELLATION.


FACTOR   A  IS THE OUTSIDE FACTOR.
```

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	243.0			
TOTAL TESTS:	240.0			
SUCCESSES:	240.0	1.000*********		
FAILURES:	0.0	0.0	*****************	

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR B IS THE OUTSIDE FACTOR.

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF

MAXIMUM TESTS POSSIBLE:	243.0		
TOTAL TESTS:	231.0		
SUCCESSES:	231.0	1.000*********	
FAILURES:	0.0	0.0	****************

TEST SUMMARY STATISTICS: DISTRIB CANCELLATION.

FACTOR C IS THE OUTSIDE FACTOR.

DISTRIBUTIVE CANCELLATION

THE VALUES PRINTED BELOW INDICATE THE DEGREE TO WHICH
THE AXIOMS ARE BEING FIT BY THE DATA.
SEE THE "CJSCAL" HANDBOOK FOR A DETAILED EXPLANATION.

	NUMBER	PERCENT OBSERVED	PERCENT EXPECTED	SIGNIF
MAXIMUM TESTS POSSIBLE:	243.0			
TOTAL TESTS:	224.0			
SUCCESSES:	224.0	1.000*********		
FAILURES:	0.0	0.0	****************	

S W A T 1:

OSU VERSION 2.0
APRIL, 1983
THOMAS E. NYGREN
DEPARTMENT OF PSYCHOLOGY
OHIO STATE UNIVERSITY
404C W. 17TH AVENUE
COLUMBUS, OHIO

N O N M E T R I C

S C A L I N G

DATA MATRIX: BLOCK 1.

MATRIX BLOCK NO. = 1 C = 1

A =	1	2	3
B = 1	1.00	4.00	7.00
B = 2	3.00	10.00	17.00
B = 3	11.00	16.00	23.00

C = 2

A =	1	2	3
B = 1	2.00	9.00	14.00
B = 2	6.00	18.00	24.00
B = 3	12.00	19.00	26.00

C = 3

A =	1	2	3
B = 1	5.00	15.00	20.00
B = 2	8.00	21.00	25.00
B = 3	13.00	22.00	27.00

PARAMETER VALUES FOR DOING CONJOINT SCALING:

NF	- NUMBER OF FACTORS IN THE DESIGN	3
N	- TOTAL NUMBER OF LEVELS OF ALL FACTORS	9
NBLKS	- NUMBER OF BLOCKS IN THE DESIGN	1
ITRLIM	- MAXIMUM NUMBER OF ITERATIONS ALLOWED	60
ITIES	- ARE TIES IN DATA TO BE LEFT AS TIES?	NO
LABEL	- ARE LABELS PROVIDED BY THE USER?	YES
NPUN	- IS FINAL SOLUTION TO BE PUNCHED ON CARDS?	NO
LASTIT	- IS SOLUTION FROM LAST ITERATION TO BE USED?	YES
NREVR	- IS INPUT DATA TO BE REVERSED?	NO
IPLOT	- IS A PLOT OF THE FIT TO BE MADE?	NO
IRAN	- RANDOM NUMBER FOR STARTING THE ANALYSIS	76655659
CRITR	- MINIMUM IMPROVEMENT CRITERION	0.00001
START	- CONSTANT TO BE ADDED TO SCALE VALUES	0.0

RANDOM STARTING CONFIGURATION:

0.452	0.392	0.280	0.158	0.424
0.123	0.919	0.408	0.177	

DATA MATRIX: SUBJECT/REPLICATION NO. 1

BLOCK	STIM	LEVELS OF FACTORS									
1	1	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0
1	2	1.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	2.0
1	3	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	5.0
1	4	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	3.0
1	5	1.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	6.0
1	6	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	8.0
1	7	1.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	11.0
1	8	1.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	12.0
1	9	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	13.0
1	10	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	4.0
1	11	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	9.0
1	12	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	15.0
1	13	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	10.0
1	14	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	18.0
1	15	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	21.0
1	16	0.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	16.0
1	17	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	19.0
1	18	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	22.0

1	19	0.0	0.0	1.0	1.0	0.0	0.0	1.0	0.0	0.0	7.0
1	20	0.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	14.0
1	21	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	20.0
1	22	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	17.0
1	23	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	24.0
1	24	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	1.0	25.0
1	25	0.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	0.0	23.0
1	26	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	26.0
1	27	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	27.0

HISTORY OF ITERATIVE COMPUTATIONS

ITERATION	THETA	TAU
1	0.45855	0.36182
2	0.05190	0.78917
3	0.02784	0.86895
4	0.03471	0.86895
5	0.03536	0.88034
6	0.03216	0.86325
7	0.03515	0.89174
8	0.03193	0.86325
9	0.03252	0.88034
10	0.03193	0.84615
11	0.03150	0.88034
12	0.03140	0.84615
13	0.03097	0.88034
14	0.03070	0.86325
15	0.03063	0.88034
16	0.03028	0.84615
17	0.03012	0.88034
18	0.03003	0.86325
19	0.02978	0.88034
20	0.02962	0.84615
21	0.02951	0.88034
22	0.02932	0.86325
23	0.02930	0.88034
24	0.02898	0.84615
25	0.02914	0.89744
26	0.02879	0.86325
27	0.02891	0.88034
28	0.02848	0.84615
29	0.02887	0.89744
30	0.02837	0.86325
31	0.02853	0.88034
32	0.02820	0.86325
33	0.02846	0.89744
34	0.02809	0.86325

35	0.02822	0.88034
36	0.02792	0.86325
37	0.02818	0.89744
38	0.02783	0.86325
39	0.02796	0.88034
40	0.02769	0.86325
41	0.02793	0.89744
42	0.02761	0.86325
43	0.02774	0.88034
44	0.02749	0.86325
45	0.02773	0.89744
46	0.02743	0.86325
47	0.02756	0.88034
48	0.02732	0.86325
49	0.02755	0.89744
50	0.02727	0.86325
51	0.02740	0.88034
52	0.02718	0.86325
53	0.02740	0.89744
54	0.02713	0.86325
55	0.02726	0.88034
56	0.02705	0.86325
57	0.02727	0.89744
58	0.02702	0.86325
59	0.02714	0.88034
60	0.02694	0.86325

SCALE VALUES BELOW ARE PRINTED FROM ITERATION NO. 60.

	VARIABLE	ADDITIVE MODEL	ADDITIVE RESCALED	MULTIP MODEL
1	TIME1	0.64196	98.04871	1.90020
2	TIME2	0.00420	34.27293	1.00421
3	TIME3	-0.33853	0.0	0.71282
4	EFFORT1	0.44491	78.34354	1.56034
5	EFFORT2	0.07085	40.93829	1.07342
6	EFFORT3	-0.32282	1.57121	0.72411
7	STRESS1	0.42791	76.64359	1.53404
8	STRESS2	0.06181	40.03439	1.06376
9	STRESS3	-0.07823	26.03014	0.92475

ADDITIVE SCALE VALUES FOR 27 STIMULI.

STIM: LEVELS STANDARD RESCALED

1	1	1	1	1.51477	225.43439
2	1	1	2	1.14868	188.82512
3	1	1	3	1.00863	174.82089
4	1	2	1	1.14072	188.02919
5	1	2	2	0.77462	151.42001
6	1	2	3	0.63458	137.41579
7	1	3	1	0.74705	148.66208
8	1	3	2	0.38095	112.05292
9	1	3	3	0.24091	98.04871
10	2	1	1	0.87701	161.65866
11	2	1	2	0.51092	125.04948
12	2	1	3	0.37088	111.04526
13	2	2	1	0.50296	124.25346
14	2	2	2	0.13687	87.64427
15	2	2	3	-0.00318	73.64003
16	2	3	1	0.10929	84.88638
17	2	3	2	-0.25680	48.27719
18	2	3	3	-0.39685	34.27293
19	3	1	1	0.53428	127.38571
20	3	1	2	0.16819	90.77658
21	3	1	3	0.02815	76.77232
22	3	2	1	0.16023	89.98053
23	3	2	2	-0.20586	53.37134
24	3	2	3	-0.34590	39.36708
25	3	3	1	-0.23344	50.61343
26	3	3	2	-0.59953	14.00426
27	3	3	3	-0.73958	0.0

DEPENDENT & PREDICTIONS SORTED BY DEPENDENT. BLOCK NO. 1.

27.000	-0.740
26.000	-0.600
25.000	-0.346
24.000	-0.206
23.000	-0.233
22.000	-0.397
21.000	-0.003
20.000	0.028
19.000	-0.257
18.000	0.137
17.000	0.160
16.000	0.109
15.000	0.371
14.000	0.168
13.000	0.241
12.000	0.381
11.000	0.747
10.000	0.503

9.000	0.511
8.000	0.635
7.000	0.534
6.000	0.775
5.000	1.009
4.000	0.877
3.000	1.141
2.000	1.149
1.000	1.515

PREDICTIVE CAPABILITY = 5.128 PERCENT
OR = 94.872 IF DATA ARE IN REVERSE ORDER.

END OF NONMETRIC SCALING ANALYSIS.

END SWAT.

END

FILMED

11-83

DTIC